Exhibit H

UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA
OAKLAND DIVISION

IN RE APPLE IPHONE ANTITRUST LITIGATION	Civil Action No. 4:11-cv-06714-YGR

EXPERT REPORT AND DECLARATION OF JEFFREY T. PRINCE, PH.D.

August 10, 2021

CONFIDENTIAL DOCUMENT
Lodged Pursuant to Local Rule 79-5(c)-(d)

Table of contents

1. INTRODUCTION

1.1. Qualifications

1. My name is Jeffrey T. Prince. I am an economist, tenured professor, and Chairperson of Business Economics and Public Policy at the Kelley School of Business, Indiana University. I am also the Harold A. Poling Chair in Strategic Management, Co-Director of the Institute for Business Analytics at the Kelley School, Advisory Committee Member for the Indiana University Center for Survey Research, and Faculty Affiliate of the Indiana University Data Science Program. From Fall 2019 to Fall 2020, I served as Chief Economist at the Federal Communications Commission.

2. A great deal of my research focuses on technology markets, consumer demand, quality competition, and data privacy. Many of my published papers utilize and analyze market data and/or survey data and involve estimates of consumer preferences for product attributes. I have developed and taught Ph.D.-level courses on empirical industrial organization, in which I have instructed students on a wide range of econometric techniques, including those assessed in this report. At the Kelley School, I have developed courses on data analysis and empirical methods that my colleagues and I have taught to senior undergraduates, MBAs, and PhDs. I am also the sole author of a recently released textbook with McGraw-Hill Education on predictive analytics and a co-author of a managerial economics book entitled Managerial Economics and Business Strategy, published by McGraw-Hill Education.

3. I graduated from Miami University with a B.S. in Mathematics and Statistics and a B.A. in Economics in 1998. I then received my Ph.D. in Economics from Northwestern University, specializing in Industrial Organization. Since earning my Ph.D. in 2004, I have published more than 25 research papers utilizing a wide range of econometric techniques, many in top economics and management journals. Appendix A provides my current CV, and Appendix B provides a list of matters in which I have given testimony.

1.2. Assignment

4. I was asked by counsel for Apple to review and respond to the expert report submitted in this matter by Plaintiffs' expert Daniel McFadden.[1] Specifically, I was asked to evaluate the reliability of Professor McFadden's methodology for providing common economic proof of impact and damages attributable to Apple's alleged conduct.

5. I have reviewed the data and materials produced in this litigation, academic literature, and other relevant public materials in reaching my conclusions. A list of materials I relied upon is provided in Appendix C. My opinions in this report are based on the materials and information available to me at this time. I reserve the right to update or supplement my opinions as additional information is made available to me. I also reserve the right to respond should Professor McFadden provide any new analysis that is not contained in his report.

6. I am being compensated at my standard billing rate of $950 per hour. I am being assisted in this matter by staff at Cornerstone Research, who are working under my direction. I receive compensation from Cornerstone Research based on its collected staff billings for its support of me in this matter. Neither my compensation in this matter nor my compensation from Cornerstone Research is in any way contingent or based on the content of my opinion or the outcome of this or any other matter. I make this declaration in support of Apple's Opposition to Consumer Plaintiffs' motion for Class Certification and Apple's Motion to Exclude the Testimony of Daniel McFadden; and Apple's Motion to Compel Plaintiffs to Submit Trial Plan.

2. SUMMARY OF OPINIONS

7. Based on my analysis of Professor McFadden's report and relevant materials, I conclude that Professor McFadden's proposed methodology is neither capable of proving with common evidence that all or nearly all members of the proposed consumer class have been harmed, nor of calculating their damages. In fact, his proposed methodology underscores that doing so would require individualized inquiries. His own model, accepted as given, finds that vast numbers of iOS accounts (as many as 29.8 million) suffered no harm. Changing his assumptions, almost without exception, substantially raises the number and changes the composition of unharmed iOS accounts. Moreover, Professor

[1] Expert Report of Daniel L. McFadden, dated June 1, 2021 ("McFadden Report").

McFadden provides no way to identify which members of the proposed class are unharmed. (*See* Opinions 1, 2, 3).

8. More fundamentally, I find that much of Professor McFadden's methodology is detached from marketplace realities and contradicts empirical evidence in a way that renders it incapable of reliably predicting the prices that any individual developer would charge absent Apple's challenged conduct.[2] For a number of independent reasons, his model cannot show impact on a common basis, nor identify with any reliability whether a given user is harmed or by how much. (*See* Opinions 4, 5, 6, 7, 8, 9).

9. Additionally, I find that Professor McFadden's sampling approach fails basic stress tests, makes wholly unreliable predictions, and does not even offer predictions for the but-for prices of most apps. (*See* Opinions 10, 11)

10. **Opinion 1.** Professor McFadden's model, even on its own terms, is incapable of showing that all or nearly all class members were injured, or of reliably identifying uninjured class members. Professor McFadden predicts that a substantial number of consumer class accounts—[redacted] million iOS accounts or [redacted] percent—are unharmed. And applying a variety of reasonable changes causes dramatic swings in both the number and the identity of unharmed accounts, precluding any effort to segregate or exclude unharmed persons from the proposed class.

11. **Opinion 2.** Professor McFadden's opinions regarding class-wide harm crucially depend on a but-for commission rate. But he does not model or analyze what commissions developers would actually pay in the but-for world, instead simplistically assuming that all developers would pay a uniform 12 percent commission. This assumption is facially implausible given the enormous prevalence of 30 percent headline rates and well-document non-uniformity in commission structures. Using alternative, reasonable assumptions more than doubles the number, and alters the identity, of unharmed accounts.

12. **Opinion 3.** Professor McFadden' model directly contradicts market reality because it excludes zero-price apps, which make up [redacted] percent of all apps in the App Store database and are a significant part of the iOS ecosystem. If it allowed

[2] Professor McFadden's opinion is that there is a single relevant market in this case. I do not accept that this is correct, but except as stated herein, or where it is obvious from the context, my opinions do not turn on the proper definition of the relevant market.

zero-price apps to respond to a commission reduction, Professor McFadden's model would find that over one third of proposed class accounts—or 68 million—are unharmed.

13. **Opinion 4.** Professor McFadden's model cannot assess the number or identity of harmed consumer accounts because he completely ignores 99 cent pricing. Price tiering policies like Apple's are commonplace and are not necessarily anti-competitive. And 99 cent prices are focal prices for many sellers. Including price tiers in Professor McFadden's model results in many developers keeping prices unchanged in the but-for world.

14. **Opinion 5.** Professor McFadden does not model competition between apps, even in the same genre, and instead makes the facially incorrect assumption that all developers set prices like monopolists. His model therefore cannot predict how developers would actually price their downloads and in-app purchases in the but-for world.

15. **Opinion 6.** Professor McFadden's model requires assuming that consumers have the same price sensitivity for all apps in the same genre. This is demonstrably false. When this restrictive assumption is dropped, the model fails to predict but-for prices at all for many apps.

16. **Opinion 7.** Professor McFadden's assumption that each developer would adjust the prices of all in-app purchase items for a given app by the same dollar amount is unrealistic and has a profound impact on which, and how many, accounts he finds are harmed.

17. **Opinion 8.** Professor McFadden's estimates of but-for app prices rely on marginal cost estimates that defy market reality, such as by underestimating the number of apps with zero or de minimis marginal costs. Because accurate marginal costs are critical to Professor McFadden's but-for price predictions, his model cannot accurately calculate harm or damage for any given app or in-app purchase, let alone do so on a class-wide basis.

18. **Opinion 9.** In Professor McFadden's model, estimates of each app's demand and marginal cost are driven not by consumer data (as he claims) but by arbitrary and incorrectly calculated margin constraints. These inputs are critical to estimating but-for prices, and removing these constraints dramatically increases the number of unharmed accounts.

19. **Opinion 10.** Professor McFadden uses a sampling method that, when applied to his model, renders it incapable of identifying which accounts, or how many, are harmed. When applied to a different random sample, Professor McFadden's model either fails completely, or results in different numbers and identities of unharmed accounts.

20. **Opinion 11.** Professor McFadden's choice to estimate prices for only a tiny subset of apps—1,806 apps out of [redacted] apps that pay commissions to Apple, and more than [redacted] apps overall—means his model cannot apply class-wide.[3] Applying Professor McFadden's to other genres produces economically nonsensical results.

3. PROFESSOR MCFADDEN'S METHODOLOGY

21. Professor McFadden asserts that a consumer is "harmed" if, as a result of Apple's challenged conduct, they paid excessive prices for apps or in-app content. Professor McFadden is not concerned with other aspects of the world that might have been different absent Apple's challenged conduct, even if some of these may have affected consumers. Professor Hitt and Professor Schmalensee address this issue further.[4] Thus, Professor McFadden's primary goal is to determine what prices would have been charged for apps or in-app content, "but for" Apple's challenged conduct.

22. In his report, Professor McFadden answers a narrower question: How would developers have priced their digital products if Apple had charged a different commission rate in the but-for world, but changed no other aspect of the iOS ecosystem? Professor McFadden provides no model or economic analysis to determine what Apple's but-for commission would have been, despite admitting that he could have done so.[5] Instead, he assumes that a single commission of 12 percent would have applied to all transactions from 2008 to 2021.[6] Professors Hitt and Schmalansee discuss why this assumption is

[3] Workpaper 1. This analysis accounts for transactions in the original App Store transactions data, ending on September 30, 2019.

[4] Expert Report of Lorin Hitt ("Hitt Report"), dated August 10, 2021, Section 6; Expert Report of Robert Schmalensee, dated August 10, 2021 ("Schmalensee Report"), Section V.

[5] Deposition of Daniel L. McFadden, dated August 3, 2021 ("McFadden Deposition"), 134:7–12 ("Q. And you haven't made any mathematical or statistical model of the but-for commission, have you? A. No. I mean, obviously, an economist could do that, and I'm aware that that could be done, but I have not done it in this case.").

[6] McFadden Report, ¶¶ 136, 161. Professor McFadden claims the but-for commission rate would have ranged from 10 to 12 percent, but the results in the main body of his report are for 12 percent.

fundamentally unrealistic and therefore unreliable.[7] I discuss its implications in § 5. The remainder of Professor McFadden's analysis then asks what developers would have charged for their apps and in-app content under this hypothetical 12 percent commission rate.

23. When choosing a price, a developer weighs how many customers it will attract against how much profit it can earn from each customer. In Professor McFadden's model, this in turn depends on three quantities: Apple's commission, assumed to be 12 percent in the but-for world; elasticity of demand; and marginal cost. Elasticity of demand measures how many customers, in the aggregate, will stop buying a product if its price goes up. Marginal cost measures how much it costs the developer to deliver the app or in-app content to one additional user.

24. While Professor McFadden can observe from App Store transaction data the actual commissions, prices, and quantities for each app and in-app purchase, he does not observe the elasticity of demand or the marginal cost. Instead, he must infer, or estimate, these quantities.[8] He claims he can use a model to determine both of these measures reliably for each paid app and in-app purchase item offered on the App Store.[9] He estimates this model using transaction data for only a 0.1 percent sample of Apple accounts—less than 400,000 accounts of the more than [redacted] accounts in the Apple transaction data, and as compared to the more than [redacted] consumer accounts belonging to the purported class[10]—combined with limited accounting data from a handful of developers. He further restricts his analysis to just 1,806 apps (as compared to more than [redacted] in the App Store) within just three genres—Games, Music, and Entertainment—and claims that he can generalize these results to other apps.

25. With these quantities in hand, Professor McFadden calculates the prices he asserts developers of these 1,806 apps would charge in the but-for world. He

[7] Hitt Report, ¶ 193 ("In reality, the most likely outcome based on historical observation of Apple and other platforms is that the App Store would charge the same commission rates in the but-for world as it has charged in the actual world."); Schmalensee Report, Section V.A ("It Is Most Likely that in the But-for World the App Store's Headline Commission Rate Would Be 30% and that Developers Would Use a Variety of Distribution Channels with a Variety of Costs.").

[8] McFadden Report, Appendix E, ¶¶ 29–31, 34, 36. In particular, he estimates price sensitivities for both downloads and in-app purchases (α^d and α^{IAP} respectively), and then obtains the elasticity of demand by multiplying the price sensitivity by the price. See Appendix F.5.

[9] McFadden Report, Appendix E.2.

[10] Second Amended Consolidated Class Action Complaint, *In re Apple iPhone Antitrust Litigation*, September 5, 2013, ¶ 54. Workpaper 2. This analysis accounts for all transactions in the full App Store database through the present.

then uses these prices, compared to the prices observed in the actual world, to determine how many accounts were harmed and by how much. He then assumes that he can scale these results to the full proposed consumer class.

26. Throughout, Professor McFadden uses "accounts" rather than "consumers" because there is no way to tie accounts precisely to individual iOS users, as I discuss in §4. In particular, a given consumer may own more than one Apple ID, and there is no common way for Professor McFadden, myself, Apple, or any other party to establish which Apple IDs belong to which individuals.

27. His methodology that I have summarized above involves many technical steps, which I explain in greater detail in Appendix D. But for reasons I explore in detail in the rest of this report, it does not reliably predict *any* economic outcomes necessary to establish consumer harm. Thus, it does not and cannot provide a reliable measure of whether, or to what extent, any individual consumer was harmed, let alone the class as a whole.

4. UNDER THE MEASURE OF HARM THAT PROFESSOR MCFADDEN ACCEPTS, A SUBSTANTIAL NUMBER OF CLASS MEMBERS ARE UNHARMED

28. Professor McFadden claims that virtually all consumers in the class were harmed by Apple's challenged conduct,[11] but his results, taken at face value, show this is false. Even ignoring any issues with Professor McFadden's methodology, his model estimates that a substantial number—[redacted] percent of the proposed consumer class, or [redacted] accounts—are unharmed by Apple's challenged conduct.

[11] McFadden Report, ¶ 13; McFadden Deposition, 196:3–7 ("Q. So is it your opinion that virtually all consumers in the class were injured by Apple's conduct? A. That is a conclusion that I reach on the basis of the model, the results.").

29. This finding occurs because, taken as given, Professor McFadden's model finds that some apps would charge *higher* prices for their downloads or in-app purchases in the but-for world. Consequently, consumers who purchase those apps or in-app purchase items would pay a higher price in the but-for world than they paid in the actual world.[12] Professor McFadden acknowledges that this means that some members of the proposed Consumer Class are unharmed by Apple's alleged conduct.[13]

30. In his report, Professor McFadden miscalculates the number of unharmed accounts. He estimates that 5.8 percent of the proposed Consumer Class, or 11.8 million accounts, are unharmed.[14] This figure is wrong for two reasons. First, Professor McFadden arrives at this result by classifying an account as harmed if the account makes any purchase that would be cheaper in the but-for world.[15] In other words, in his report, Professor McFadden classifies as harmed an account that makes 100 purchases that would be more expensive in the but-for world, as long as that account had made a single purchase that he predicts would be cheaper in the but-for world. This is an incorrect measure of harm.

[12] McFadden Report, ¶ 240 ("I note that there are a relatively small number of apps for which either download or in-app purchase prices are estimated to increase somewhat in the But-For world.").

[13] McFadden Deposition, 195:22–196:2 ("Q. …you are not offering an opinion that 100 percent of consumers in the class were injured, is that correct? A. …correct. That….is not a necessary opinion for the analysis and is not implied by the analysis.").

[14] This result is based off a calculation of [redacted] consumer accounts with at least one paid download or in-app purchase in the full App Store database through the present. Hitt Report, ¶ 70. Workpaper 3. This analysis accounts for all transactions in the full App Store database through the present. Professor McFadden asserts that his estimate that 5.8 percent of the consumer class is uninjured is conservative. He claims this follows from the fact that he has not analyzed any categories of apps other than Games, Music, and Entertainment (and hence, perhaps the uninjured consumers he found considering Games, Music and Entertainment were injured elsewhere) and also because he believes some individuals who are not included in the Plaintiffs' defined class might be injured.[14] This is wrong. Professor McFadden's calculation is not conservative because, as discussed below, he uses an incorrect metric for assessing harm—he does not assess the consumer's *net* purchases.

[15] McFadden Report, ¶ 226. All of Professor McFadden's counts of consumers are actually counts of accounts. I discuss this problem further in Section 4.2.

31. Professor McFadden changed this opinion during his deposition. In particular, he correctly noted that to determine whether an account is harmed, one should consider the total cost of all the purchases an account makes in both the actual world and the but-for world. If the total cost using but-for prices is higher than (or equal to) the total cost using actual prices, this account is unharmed.[16] I agree with Professor McFadden and use this "net" measure of harm to calculate that [redacted] percent of the proposed Consumer Class, or [redacted] accounts are unharmed (not accounting for the second error described next). I use this measure of harm for the remainder of the report.

32. Second, Professor McFadden makes a basic data processing error. In his analysis, Professor McFadden excludes apps in years where they do not have the same price in all months of the year. However, he also excludes apps that have prices that are really the same. For example, if an app shows a price of $0.99000000 in one month and a price of $0.99000001 in another month of the same year, Professor McFadden treats them as different prices and drops all observations pertaining to that app for that year from his analysis. This is wrong because such a difference in prices is due to a data processing error rather than some feature of the marketplace. When this error is corrected, Professor McFadden's own model shows that [redacted] percent of the proposed Consumer Class, or [redacted] accounts, are unharmed using the "net" measure of harm. Even using the incorrect measure of harm used by Professor McFadden in his report, his model shows that [redacted] percent of the proposed Consumer Class, or [redacted] accounts, are unharmed.[17] The magnitude of this error is so significant because the erroneously dropped apps have on average more than 25 times as many downloads as apps that Professor McFadden keeps, and are more than twice as likely to be priced at $0.99.[18] As I discuss in §6.1, in Professor McFadden's model, low-priced apps are likely to increase their prices in the but-for world.

[16] McFadden Deposition, 201:22–202:3 ("Q. Okay. So you agree that if a consumer spent money on an app whose but-for price is lower than [and] another app whose but-for price is higher, the net harm of Apple's conduct would need to account for both those price changes; is that right? A. Yes, that's the way I do it, and I think that's economically appropriate. Q. And if the net is…positive, then the consumer has not been harmed, correct? A. That would be correct, yes.").

[17] Workpaper 4. This analysis accounts for all transactions in the full App Store database through the present.

[18] Workpaper 5. These statistics are in terms of app-year combinations, and they also consider only apps with paid downloads, since only paid download apps are subject to Professor McFadden's error.

33. I discovered this data processing error in Professor McFadden's analysis on the eve of finalizing my report. Therefore, the remainder of this report presents analyses that do not correct for this error because it was not computationally feasible to do so at that time. I reserve the right to amend or expand my analyses to account for Professor McFadden's data processing error.

4.1. Changing the unrealistic assumptions of Professor McFadden's model generates even more unharmed accounts

34. The number of unharmed accounts discussed above accepts Professor McFadden's model as it is. However, Professor McFadden makes a number of unrealistic assumptions that are completely disconnected from market realities. In each case, applying an alternative, reasonable assumption leads to a dramatic increase in the number of unharmed accounts, which means that Professor McFadden's model severely overestimates the fraction of the proposed class that is harmed.

35. Exhibit 1 summarizes these results. In the remainder of this report (especially §§5, 6, and 7), I discuss each issue in detail and the impact of changing these assumptions on conclusions about harm to the proposed class.

EXHIBIT 1
Changing the unrealistic assumptions of Professor McFadden's model generates even more unharmed accounts

Professor McFadden			Alternative		
	"Unharmed" accounts			"Unharmed" accounts	
Assumption	[redacted]	[redacted]	Assumption	[redacted]	[redacted]
The but-for world with a 12 percent commission rate begins July 10, 2008	[redacted][2]	[redacted][2]	But-for commisions were the same as actual commissions through October 31, 2017. 12 percent commission rate after this date	[redacted][2]	[redacted][2]
All apps pay 12 percent uniform commission in but-for world	[redacted]	[redacted]	First $10 million of lifetime revenue for each app is subject to actual commission in but-for world	[redacted]	[redacted]
Free apps are excluded	[redacted][2]	[redacted][2]	Free apps are included and can change their prices in the but-for world	[redacted][2]	[redacted][2]
Impose arbitrary constraints during demand estimation	[redacted]	[redacted]	Do not impose constraints during demand estimation	[redacted]	[redacted]
All in-app purchase items for the same app change their prices by the same dollar amount in the but-for world	[redacted]	[redacted][3]	Developers can change the prices of different in-app purchase items by different amounts	[redacted]	[redacted][3]

Source: Prince Exhibits 3, 4, 5, 8, 9, 11.
Note: [1] Results are given in terms of [redacted] in the proposed consumer class. [2] These statistics are computed as a fraction of accounts that appeared in both Professor McFadden's analysis and the analysis with an alternative assumption. This means that the collection of accounts evaluated differs in these rows. Therefore, the left hand numbers do not exactly match the other rows. [3] These results assume that only Roblox is granted this freedom, and consider only accounts that made at least one Roblox paid transaction. This means that the collection of accounts evaluated differs in this row. Therefore, the left hand numbers do not match the other rows. Due to the special set of accounts considered, there is no straightforward way to scale these percentages to the full consumer class, so I offer findings only in percentages.

4.2. Professor McFadden's model cannot identify which consumers are harmed

36. While Professor McFadden's model predicts that a substantial number of accounts are unharmed by Apple's challenged conduct, this does not mean that his model can reliably identify which consumers are harmed. It cannot do so for two reasons: the identities of harmed accounts changes when Professor McFadden's unrealistic assumptions are changed, and Professor McFadden cannot link accounts with individual consumers.

37. First, Professor McFadden cannot reliably determine which accounts are harmed that set changes when his unrealistic assumptions are changed. As I explain in §8, his model yields dramatically different predictions about the number of unharmed accounts (and, therefore, which accounts are harmed), even when it is run in exactly the same way, but on a different sample of data. Further, as I discuss in §§5, 6, and 7 and summarize in Exhibit 2, adjusting Professor McFadden's unrealistic assumptions to bring them more into line with market realities dramatically changes the identities of unharmed accounts. This means his model cannot be used to determine which accounts are harmed in any reliable manner.

EXHIBIT 2
Changing the unrealistic assumptions of Professor McFadden's model changes the identities of unharmed class members

Professor McFadden's assumption	Alternative	Accounts that switch (percent)[1]
The but-for world with a 12 percent commission rate begins July 10, 2008	But-for commisions were the same as actual commissions through October 31, 2017. 12 percent commission rate after this date	[redacted][2]
All apps pay 12 percent uniform commission in but-for world	First $10 million of lifetime revenue for each app is subject to actual commission in but-for world	[redacted]
Free apps are excluded	Free apps are included and can change their prices in the but-for world	[redacted][2]
Impose arbitrary constraints during demand estimation	Do not impose constraints during demand estimation	[redacted]
All in-app purchase items for the same app change their prices by the same dollar amount in the but-for world	Developers can change the prices of different in-app purchase items by different amounts	[redacted][3]

Source: Prince Appendix E, Exhibits 3, 4, 5, 8, 9, 11.

Note: [1] This is the fraction of accounts that have different harm determinations under Professor McFadden's assumption and the Alternative. That is, they either switch from harmed to unharmed, or vice-versa. [2] These statistics are computed as a fraction of accounts that appeared in both sensitivities. [3] These results assume that only Roblox is granted this freedom, and consider only accounts that made at least one Roblox paid transaction

38. Second, Professor McFadden cannot determine which consumers are unharmed because he cannot identify all the purchases made by the consumer. A consumer is harmed only if the total cost of all of their purchases is lower in the but-for world compared to the actual world. Therefore, in order to demonstrate harm for a consumer, it is crucial that Professor McFadden identify all their purchases. But Professor McFadden cannot do so because he only observes Apple IDs rather than consumer identities.[19] Some consumers have multiple Apple IDs, and Professor McFadden states that "it is not possible to link different ID's held by the same person."[20] Professor McFadden agrees that doing so would not be a "practical possibility" and would instead be a "Herculean task."[21] Therefore, it is impossible for Professor McFadden to determine the full set of apps downloaded and the total spending on apps and in-app purchases at the consumer level, and it is impossible for him to determine whether individual consumers have been harmed. Instead, he assesses harm for each account rather than each consumer.[22] Despite the insufficiency of this approach, I will do the same for the purposes of this report.

[19] McFadden Report, ¶ 139.

[20] McFadden Report, n. 199.

[21] McFadden Deposition, 227:4–229:22 ("Q. If there are consumers who have multiple Apple IDs, isn't a fact that you will be unable to determine whether those consumers are injured unless you net out all the transactions carried out by the total set of their IDs?...THE DEPONENT: The answer is that the calculation has to be done by Apple ID because the transactions database...does not tell you anything about whether different Apple IDs are associated with a single person or not...and as far as I know, Apple itself would not know whether separate Apple IDs are coming from the same person or not. So that I think that it is beyond the reach of Apple or the plaintiffs to...try to merge Apple IDs attached to a single individual or to a single family, or to a single payer. That might be the economic ideal, but I think that is beyond the bounds of practically...Q. If there was a class member who had two Apple IDs and your calculation showed that one of the Apple IDs was negligently injured and the other Apple ID was very much better off, in the but-for world, would you be able to determine whether that individual was injured?...THE DEPONENT: As...I've indicated, there is simply nothing in the transactions database which would allow that kind of...identification. So it's a... hypothetical which has no...practical possibility of...implementation. So the answer is, of course, if you could...group Apple IDs by...payers, you could then do these calculations and compensat[e] each payer appropriately. But that's...beyond the pale of practically or possibility. And so the best you can do is look at each app owner that's...those are data that Apple has, presumably. They know...a credit card or some payment mechanism for their...customers. So...a scheme to compensate them could be conducted by Apple. I would...say that if...Apple...chose to try to match different accounts for individuals and made that available to the plaintiffs, the plaintiffs could certainly use it in the same spirit as...we do things currently. So I would just leave it as an open invitation to Apple if they are willing to undertake that Herculean task, that would be beneficial perhaps to resolution of the case.")

[22] McFadden Report, n. 199.

5. PROFESSOR MCFADDEN'S BUT-FOR COMMISSION RATE IS WRONG AND BASED ON NO MEANINGFUL ANALYSIS

5.1. Professor McFadden provides no analysis of Apple's but-for commission and ignores the ubiquity of 30 percent headline rates

39. Professor McFadden has not provided a reliable method for demonstrating common harm to the members of the proposed Consumer Class; he has assumed it. Professor McFadden conceded during his deposition that his approach is designed to find a common effect, without first investigating whether the effect is, in fact, common.[23] A clear example of this is his treatment of the but-for commission rate.

40. As discussed in Section 3 above, all of Professor McFadden's conclusions depend critically on predicting accurately what prices each developer would charge in the but-for world under a different, and known, commission rate.[24]

41. Despite the importance of Apple's but-for commission rate, Professor McFadden does not actually model how Apple would set it.[25] Apple's but-for commission rate would depend on how customers (consumers and developers) decide where they would engage in transactions, how various app stores would differentiate themselves to attract customers, or how various app stores would set their commissions and other fees.[26] Instead of modeling these factors, he simply states that, in the but-for world, "the force of competition would bring down the commission rate."[27] He does not explain how this would occur, and in fact at his deposition admitted that he did not know what salient features of the

[23] See, e.g., McFadden Deposition, 174:5–22 ("Q. Does your model assume that all apps in the same category or genre face demand functions with the same price sensitivity? A. Yes…the current model…has that form. It…could be elaborated if there is evidence available that there are significant variations from that over…the apps. Q. Well, did you have any empirical basis for the assumption that you made? A. I would say that…it's not an empirical assumption. It's a….modeling assumption…you start a model. You keep it as…simple as you can to capture the effects you need to capture, and so…the starting point is the simple assumption that there's a common…effect, and you elaborate the model…if you need to.").

[24] McFadden Report, Appendix E, ¶ 46.

[25] McFadden Deposition, 134:7–12 ("Q. And you haven't made any mathematical or statistical model of the but-for commission, have you? A. No. I mean, obviously, an economist could do that, and I'm aware that that could be done, but I have not done it in this case.").

[26] Developer Plaintiffs' Expert Professor Elhauge discusses that, in the but-for world, iOS app distributors would be differentiated both vertically (meaning that consumers on average would see some as superior) and by business strategy (meaning that some distributors would try different methods to attract customers). He argues that these features would mean that the different distributors would likely charge different prices. See Expert Report of Einer Elhauge, dated June 1, 2021 ("Elhauge Report"), ¶¶ 324–328. Therefore, one must have a reasonable understanding of these factors in order to project but-for commissions.

[27] McFadden Report, ¶ 154.

but-for world would look like,[28] including how many rival iOS app stores would enter,[29] whether any would enter,[30] or what the App Store's market share would be.[31] He also admitted he had "no idea" how long it would take for the commission to fall to his assumed 12 percent level.[32] Professor McFadden's model fails to offer any economic basis for his assumed but-for commission rate for Apple and, in turn, any of his predictions in the but-for world. It assumes its conclusion.

42. Furthermore, Professor McFadden's assumption that all transactions during the class period would have been subject to a uniform 12 percent commission rate is facially implausible. Most notably—and as Professor Hitt explains in more detail—Professor McFadden's assumption ignores that app stores have charged a 30 percent headline commission rate like Apple's for substantial stretches of the class period and in the face of head-to-head competition from other stores on the same device.[33] This is true even for the PC game stores Professor McFadden takes as benchmarks.[34]

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[28] McFadden Deposition, 130:20–23 ("In fact, to go further, I have offered no opinion on the…form competition would compare to pressures would lead Apple to lower its commission."); 131:19–132:5 ("Q. Do you have any opinion as to the App Store's market share on the but-for world? A.…No, I don't because I…am not offering any opinion that the but-for world would have a specific industrial structure in terms of whether rivals are actually present; whether rivals are potential. As I just mentioned, they might be achieved by limit pricing. It might be achieved by actual entry. It might be achieved by other…mechanisms which are possible competitive responses.").

[29] McFadden Deposition, 130:17–20 ("Q. Professor, in the but-for world, how many rival iOS app stores will there be? A. I have not offered any…opinion on that.").

[30] McFadden Deposition, 131:7–18 ("Q. If you believe that that could be achieved through limit pricing, does that mean that your but-for world is consistent with no actual entry?…THE DEPONENT: Yes, my but-for world is consistent with a…situation in which Apple rules allowed entry, but it sets its commissions in such a way that potential entrants found it unprofitable to come in…that's what limit pricing does, and that's certainly a possible outcome.").

[31] McFadden Deposition, 131:19–132:5 ("Q…Do you have any opinion as to the App Store's market share on the but-for world? A. The answer is: No, I don't because I…am not offering any opinion that the but-for world would have a specific industrial structure in terms of whether rivals are actually present; whether rivals are potential. As I just mentioned, they might be achieved by limit pricing. It might be achieved by actual entry. It might be achieved by other…mechanisms which are possible competitive responses.").

[32] McFadden Deposition, 151:1–13 ("Q. In the but-for world, how much time would it take before entry would lead Apple to charge the 10 to 12 percent but-for commission level that you use as a benchmark?…THE DEPONENT: I have…no idea…[that] would be, I think, a difficult calculation for…economists,…because it…depends on the detailed evolution of the structure of the market, and that's…much harder to predict than to predict that competitive pressures, in general, will operate on some timescale.").

[33] Hitt Report, ¶ 79 ("[W]ith limited exceptions, each app transaction platform has set the same headline commission rate as the headline commission rate on the App Store – 30 percent.").

[34] Hitt Report, ¶ 78 ("While app transaction platforms serving mobile devices, PCs, and consoles share a common 30 percent headline commission rate, there has not been, and is not, any single, consistent commission rate below 30 percent that applies for all app transaction platforms for any type of device.").

5.2. Changing Professor McFadden's unrealistic but-for commission assumption results in more than 20 percent of accounts unharmed

43. Given the enormous prevalence of 30 percent commission rates, it is reasonable to consider what Professor McFadden's model would predict if Apple were to retain this rate for at least some transactions in the but-for world. Indeed, Professor Hitt says that "market facts show that the predominant headline commission rate would be 30 percent."[35] I find that running Professor McFadden's model using such assumptions unvaryingly yields a large increase in the number and identity of unharmed accounts.

44. To illustrate how important it is that Professor McFadden has ignored the ubiquity of 30 percent commission rates, I have run Professor McFadden's model using three alternative commission assumptions in which that rate is retained for some or all app transactions:

- No change in Apple's commissions from the actual world, meaning that most apps would pay a 30 percent commission in the but-for world.[36]
- No change in Apple's commissions from the actual world through October 2017, meaning a headline 30 percent commission until that point.[37]
- A tiered commission structure, with no change in Apple's commissions from the actual world for low-revenue apps, meaning that most low-revenue apps would pay a 30 percent commission in the but-for world.[38]

[35] Hitt Report, ¶ 192.

[36] Hitt Report, ¶ 193 ("In reality, the most likely outcome based on historical observation of Apple and other platforms is that the App Store would charge the same commission rates in the but-for world as it charged in the actual world."). Apple does not actually apply a 30 percent commission to every transaction; Professor Hitt describes some exceptions to this, including long-running subscriptions. See Hitt Report, ¶ 52. To avoid assuming that commissions would ever have been *higher* in the but-for world for any transaction, I applied Apple's actual world commission (whether 30 percent or lower) to all transactions in the but-for world.

[37] Hitt Report, ¶ 98 ("Since October 26, 2017, non-game PC app transaction on the Microsoft Store have been subject to a headline commission rate of 15 percent, and in some instances developers of non-game PC apps could obtain a lower commission rate."), ¶ 138 ("Had Professor Economides accurately reflected changes in time in the commission rates charged by the PC app transaction platforms he analyzed, he would have found the headline third-party commission rates up until December 2018 would have been 30 percent for game apps, while the headline third-party commission rates up until October 2017 would have been 30 percent for non-game apps."). Apple does not actually apply a 30 percent commission to every transaction; Professor Hitt describes some exceptions to this, including long-running subscriptions. See Hitt Report, ¶ 52. To avoid assuming that commissions would ever have been *higher* in the but-for world for any transaction, I applied Apple's actual world commission (whether 30 percent or lower) to all transactions through October 2017.

[38] Hitt Report, ¶ 92 ("Before November 30, 2018, Valve charged a 30 percent commission on games sold through the Steam platform. On November 30, 2018, Steam established a commission rate of 30 percent for the first $10 million in lifetime net sales (after subtracting commissions) for an app, 25 percent for lifetime net sales between $10 million and $50 million for an app, and a commission rate of 20 percent for lifetime net sales over $50 million for an app."), ¶ 218 ("Once an app has reached $10 million in lifetime revenues on Steam, Valve lowers the commission rate to 25 percent on all transactions. In addition, once an app has reached $50 million in

45. First, if Apple's but-for commissions are the same as in the actual world—consistent with a 30 percent headline commission throughout the class period—Professor McFadden's model predicts that no accounts are harmed. In Professor McFadden's model, Apple's commission must change in the but-for world for there to be any change in developer prices; it is only the change in the commission rate between Professor McFadden's modeled actual and but-for worlds that causes a change in developer prices.[39]

46. Second, if Apple's but-for commissions are the same as in the actual world through October 2017—when Microsoft lowered its commission rate for non-game PC app developers—Professor McFadden's model predicts far more unharmed accounts than in Professor McFadden's reported results. Applying Professor McFadden's model to this scenario, and changing no other aspects, yields an increase in the number of accounts that are unharmed from [redacted]. Exhibit 3 illustrates these results.[40]

lifetime revenues on Steam, Valve further lowers the commission rate to 20 percent on all future transactions."). Apple does not actually apply a 30 percent commission to every transaction; Professor Hitt describes some exceptions to this, including long-running subscriptions. See Hitt Report, ¶ 52. To avoid assuming that commissions would ever have been *higher* in the but-for world for any transaction, I applied Apple's actual world commission (whether 30 percent or lower) to the first $10 million of lifetime revenue in the but-for world.

[39] McFadden Report, Appendix E, ¶¶ 41–45.

[40] These numbers assume that each in-app purchase item for the same app changes price by the same dollar amount. I have computed alternative numbers assuming that each in-app purchase item for the same app changes price by the same percentage amount. The findings are qualitatively similar and even stronger. Workpaper 6. This analysis accounts for all transactions in the full App Store database through the present.

EXHIBIT 3
Unharmed accounts if but-for commissions were the same as actual commissions through October 2017

Source: McFadden Production

Note: These results apply Professor McFadden's methods exactly, except that they set but-for world commisisons equal to actual-world commissions through October 2017. After this, all apps pay a 12 percent commission. 2017 is treated as two separate years: January through October; and November through December. The orange bar provides a comparison to Professor McFadden's original results.

Furthermore, it is not only that the number of accounts that are unharmed rises in each case. Exhibit 1 in Appendix E shows that which accounts are harmed changes. Over [redacted] of accounts in Professor McFadden's sample change from harmed to unharmed, or vice-versa, when but-for commissions equal actual commissions through October 2017.

47. Third, applying a but-for commission that is similar in spirit to Steam's current structure again predicts that far more accounts would be unharmed. I ran Professor McFadden's Model assuming that, like Steam does in the actual world, Apple would charge a 30 percent headline commission on the first $10 million of lifetime revenue for every app.[41] I conservatively maintain Professor

[41] See n. 37 above. I assume that developers currently facing a 30 percent commission, but anticipating that they will eventually face a 12 percent commission when they reach $10 million in lifetime revenue, will behave today as though they face a 12 percent commission. This is conservative because these developers may not fully

McFadden's 12 percent but-for commission for all subsequent revenue, even though Steam charges higher commissions than this. In all other respects, I leave Professor McFadden's approach unaltered. Exhibit 4 shows that, under this assumption, the number of accounts that are unharmed increases from [redacted].[42]

EXHIBIT 4
"Unharmed" accounts if apps under $10 million in lifetime revenue paid same commissions in but-for world.

Source: McFadden Production

Note: These results apply Professor McFadden's methods exactly, except that they require an app to reach $10 million in lifetime revenue to qualify for the lower, 12 percent but-for commission Professor McFadden proposes; if an app ever reaches that threshold, I assume it pays the 12 percent commission on *all* transactions, including the first $10 million, in order to be conservative. Otherwise, the app pays the same commission in the but-for world that it paid in the actual world. The orange bar provides a comparison to Professor McFadden's original results.

Exhibit 2 in Appendix E shows that which accounts are harmed changes. Over 13 percent of accounts in Professor McFadden's sample change from harmed to

anticipate their future revenue, and in early years before they hit $10 million in lifetime revenue, they may still price according to the 30 percent commission.

[42] These numbers assume that each in-app purchase item for the same app changes price by the same dollar amount. I have computed alternative numbers assuming that each in-app purchase item for the same app changes price by the same percentage amount. The findings are qualitatively similar and even stronger. Workpaper 7. This analysis accounts for all transactions in the full App Store database through the present.

unharmed, or vice-versa, when in the but-for world, each app's first $10 million in lifetime revenue is subject to a 30 percent headline commission.[43]

48. These results reinforce a familiar fact—the vast majority of apps in the App Store generate very little revenue.[44] Under a commission policy like Steam's that subjects the vast majority of purchases to a 30 percent commission, many developers would not qualify for any lower commission than they pay now. Accounts that made paid transactions only or predominantly with these apps would see little to no benefit from a Steam-like commission structure that adjusts the commission only for large developers.

49. In summary, Professor McFadden's results depend directly and fundamentally on the incorrect assumption that all developers would pay a uniform, 12 percent commission in the but-for world. Changing this assumption in ways that acknowledges Apple would likely still charge 30 percent on many transactions (and for some if not all of the class period) leads to large changes in both how many accounts are unharmed and which accounts are harmed.

6. PROFESSOR MCFADDEN'S MODEL IS DISCONNECTED FROM THE REALITIES OF THE MARKET IT STUDIES

50. Professor McFadden's model is incapable of reliably predicting the prices any individual developer would charge absent Apple's challenged conduct because the model is entirely disconnected from the realities of the market it studies. In particular, it completely ignores the role of free apps (i.e., apps that are free to download and do not offer in-app purchases), Apple's current and expected discrete price tiers, and competition among apps. Additionally, Professor McFadden makes unrealistic assumptions about developers' pricing decisions for in-app purchases. Changing these assumptions has a profound impact on which, and how many, accounts Professor McFadden would find are harmed. Finally, the marginal costs that Professor McFadden estimates using his model are facially inconsistent with market realities, showing that his entire approach is incorrect.

[43] See n. 37 above.

[44] Hitt Report, Exhibit 10.

6.1. Professor McFadden erroneously ignores free apps, and accounting for them leaves one third of accounts unharmed

51. Professor McFadden excludes from his analysis, and predicts no but-for price for, all free-to-download apps that do not offer in-app purchases ("free apps").[45] As discussed by Professor Schmalensee and Professor Hitt, these apps are an important part of the iOS ecosystem and should be considered in any analysis.[46] Indeed, [redacted] of all apps in Professor McFadden's 0.1 percent sample, and [redacted] of all apps in the App Store database overall, are completely free.[47]

52. Professor McFadden's own model and logic predict that free apps would raise their prices in the but-for world had he included them in his analysis.[48] If accounted for, these price increases would dramatically alter whether any given account would be better off in the but-for world and would lead to an estimate that more than one-third of accounts, or [redacted], are uninjured.[49]

53. As explained in more detail in Appendix F.7, in Professor McFadden's model, developers with apps that have low elasticities of demand will raise their prices in the but-for world, as they would expect to lose relatively few customers when their prices go up. His model also implies that apps with lower prices will all have lower elasticities of demand. Therefore, it would find that all developers of free apps—apps with a price of $0.00 that do not offer in-app purchases—would have an incentive to raise their prices in the but-for world.[50]

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[45] McFadden Report, ¶ 184. McFadden Deposition, 67:1–3 ("Generally, in the…modeling and econometric work I've done, we have excluded free apps and dealt only with…paid apps.").

[46] Hitt Report, ¶ 276 ("[I]t is necessary to determine whether the developer might alter its pricing strategy overall, such as charging for what were formerly free apps."); Schmalensee Report, ¶ 170 ("These results show that plaintiffs' neglect of both free apps and advertising is a particularly serious flaw in their analyses. In fact, free apps account for over 80 percent of apps in the App Store and these apps often compete with apps in the developers' class… Therefore, if plaintiffs' remedies for a developer class that includes only 5 percent of all developers will reduce the attractiveness of the App Store to developers of free apps, such remedies have the potential to harm the other 95 percent of all developers that have transacted with consumers through the U.S. App Store storefront during the developer class period.").

[47] Workpaper 8. This analysis accounts for transactions in the original App Store transactions data, ending on September 30, 2019.

[48] See Appendix F.1.

[49] See Exhibit 5 below.

[50] I am not offering the opinion that all such developers would actually raise their prices—merely that the most straightforward extension of Professor McFadden's model to free apps has this implication. Note that a proper analysis of free apps would account for at least two phenomena that currently lie outside the scope of a straightforward extension of Professor McFadden's model. First is the "free" effect—the empirical finding that consumers prefer free goods and services to a far greater extent than would be expected, given their preferences between more expensive and less expensive non-free goods and services—i.e., there is something "special" about "free." See, e.g., Kristina Shampanier et al., "Zero as a Special Price: The True Value of Free Products," *Marketing Science*, 26(6), 2017, pp. 742–757 at p. 742; Juan L. Nicolau and Ricardo Sellers, "The Free Breakfast Effect: An Experimental Approach to the Zero Price Model in Tourism," *Journal of Travel Research*, 51(3), 2012, pp. 243–

54. This incentive to raise prices in the but-for world is not an artifact of technical assumptions of Professor McFadden's model, but rather reflects a particular incentive such apps will face. Take, for instance, free apps that monetize through advertising revenue. As Professor Willig explains, such apps may choose to raise their prices in the but-for world.[51] Rather than accounting for such an eventuality, Professor McFadden precludes this phenomenon from affecting his results by ignoring free apps in his analysis.

55. I investigate the importance of Professor McFadden's exclusion of free apps by reintroducing them to his model in the most straightforward way possible: I treat them as paid download apps with an actual-world price of $0.00.[52] In order to include these apps, I needed to make the following two adjustments to Professor McFadden's methods: (1) whereas Professor McFadden predicts prices for only the top apps by revenue (which would, by definition, exclude free apps), I focus on the top apps by downloads in order to capture popular apps excluded from Professor McFadden's analysis; (2) when estimating demand, I exclude free apps from the profit margin constraints imposed by Professor McFadden (since these apps have an undefined profit margin at a price of zero).[53] Otherwise, I use Professor McFadden's formulas and methods exactly as they are. This methodology provides me with Professor McFadden's actual-world and predicted but-for prices of apps—including free apps—and in-app purchases, which I then use to determine how many, and which, accounts Professor McFadden would label as "harmed" if he were to include free apps.

56. Exhibit 5 shows that, when I include free apps in Professor McFadden's model, significantly more accounts are classified as unharmed.[54] In particular, the number of estimated unharmed accounts rises from [redacted], as Professor McFadden's model predicts

249 at p. 244. Second is the issue of a "corner solution." Developers may set the price at zero when the true, profit-maximizing price would be negative—i.e., they would prefer to pay users to install the app, but the App Store does not currently allow this. This is related to the issue of price tiers, which I discuss in §6.3. Professor McFadden's model cannot account for these phenomena.

[51] Expert Report of Robert D. Willig, dated August 10, 2021, ¶ 231 ("In this circumstance, a lower commission rate would give the developer an incentive to *increase* its subscription price. In other words, consumers would pay more in the but-for world for subscription apps that generate revenue from in-app advertising.").

[52] This approach involves fewer assumptions than allowing free apps to start creating and charging for in-app purchases. In particular, the transaction data capture downloads of free apps and their prices ($0.00 for free apps). These are the only two pieces of information required to include paid download apps in Professor McFadden's model.

[53] I also represent that the actual-world commission rate that would apply to a free app download is 30 percent.

[54] See Exhibit 5 below.

that, for these accounts, any lower prices from paid downloads are more than offset by higher prices for free apps in the but-for world.[55]

EXHIBIT 5
"Unharmed" accounts if free apps can raise their prices in the but-for world

Source: McFadden Production

Note: These results apply Professor McFadden's methods exactly, except that they (1) include the apps accounting for the top 70 percent of downloads instead of Professor McFadden's top 70 percent of revenue (in any year, within their genre); and (2) they allow free apps to change their prices in the but-for world. Specifically, they treat free apps as paid download apps with actual world prices of $0.00 and actual world commissions of 30 percent. The orange bar provides a comparison to Professor McFadden's original results. Because the set of apps for which a but-for price is computed has changed, so has the set of consumers with a harm determination. These results focus on the consumers receiving a harm determination both under Professor McFadden's original analysis and under this new analysis.

As shown in Exhibit 3 in Appendix E, which consumers are harmed also changes when free apps are included: Over [redacted] of accounts in Professor McFadden's sample that also receive a harm determination in this new analysis[56] change from harmed to unharmed, or vice-versa, when free apps are included.

[55] These numbers assume that each in-app purchase item for the same app changes price by the same dollar amount. I have computed alternative numbers assuming that each in-app purchase item for the same app changes price by the same percentage amount. The findings are qualitatively similar and even stronger. Workpaper 9. This analysis accounts for all transactions in the full App Store database through the present.

[56] Because the set of apps for which a but-for price is computed has changed, so has the set of consumer accounts with a harm determination (i.e., accounts that made at least one paid transaction for an app for which a but-for price is computed). These results focus on the consumer accounts receiving a harm determination both under Professor McFadden's original analysis and under this new analysis.

6.2. Professor McFadden's disregard of Apple's price tiers and focal-point pricing means he underestimates how many proposed class members are unharmed

57. As Professor McFadden acknowledges, the App Store requires apps to price according to tiers that "range[] from $0.99 to $999.99 with dollar increments up to $49.99," with other increments up through $999.99.[57] However, he states that price tiers are anticompetitive and therefore removes them from his but-for world.[58] This omission causes Professor McFadden to grossly overestimate how often apps would lower prices in his but-for world, which directly leads to overestimating the number of harmed consumers and renders his model unreliable.

58. Contrary to Professor McFadden's assertions, Professor Schmalensee provides convincing reasons why Apple's price tiers are not anticompetitive.[59] Thus, Professor McFadden is incorrect to exclude them from the but-for world. However, even if Apple were to remove price tiers in the but-for world, evidence suggests that many developers would still price their apps at focal points ending in 99 cents. For example, Google Play does not have price tiers like the App Store, but many developers choose a price ending in 99.[60] Professor McFadden failed to even consider the impact of such focal pricing in his model.[61] Therefore, Professor McFadden's assumption that Apple would not have price tiers or focal price points ending in 99 cents in the but-for world is arbitrary, lacks foundation, and is incorrect.

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[57] McFadden Report, ¶ 128.

[58] McFadden Report, ¶ 162. In his deposition, Professor McFadden confirmed that he thinks the price-tier structure is anticompetitive. See McFadden Deposition, 122:10–16 ("Q…are you offering an opinion that Apple's 99-cent-price-tier structure is anticompetitive? A. Yes. I would say, as a matter of economics, tier…structures have a…substantial effect on the nature of…competition.").

[59] Schmalensee Report, ¶ 211 ("Professor McFadden argues that Apple's $0.99 pricing restriction limits competition and is therefore anticompetitive, but performs no analysis beyond claiming that price tiers 'interfere with app developers' ability to compete'…Of the top 100 paid apps on Steam, Amazon App Store, and Microsoft Store, at least 85, 90, and 75 respectively have prices ending in .99, even though none of these stores not impose the .99 pricing restriction."). Schmalansee Report, ¶ 75. ("… developers have been able to choose a price for their apps from a very wide range of price tiers that include $0 on the lower end and $999.99 on the upper end. Since the App Store's launch, all changes to Apple's pricing policy have served to expand business opportunities for developers.").

[60] Schmalensee Report, ¶ 211 ("Even though Google Play does not impose the same $.99 pricing restriction, for instance, of Google Play's top 100 paid apps, 83 have prices ending in .99."); Hitt Report, ¶ 366 ("While Google Play does not require developers to choose a price from a set of possible price tiers, it does set a minimum price of $0.99, and in practice, most developers choose a price ending in 99.").

[61] McFadden Deposition, 180:18–181:6 ("The answer is: No, the model does not take that into account. Could it? If -- if there were -- if there were a symptomatic pattern of consumers misinterpreting prices to focal points, then that -- the model could be easily modified to take that into account. But I -- I would say that, in my -- in my opinion, with some experience in both consumer work and -- and behavioral economics, that these – the

59. By assuming that price tiers would disappear, and app developers would charge prices all along the pricing continuum in the but-for world, Professor McFadden is overestimating the number of consumers that are harmed, even excepting the other problems with his approach. To understand why, consider Toca Lab: Elements, a paid download Entertainment app that was priced at $2.99 in the real world in 2016.[62] Professor McFadden finds that this app would decrease its price by $0.41 in the but-for world. Under Professor McFadden's assumption, the developer now prices the app at $2.58 in the but-for world, and Professor McFadden infers that consumers of this app in the real world were harmed by $0.41. However, a download price of $2.58 is not compatible with Apple's price tier policy. Importantly, it is more profitable for this app to retain its price of $2.99 rather than drop its price all the way to $1.99 in the but-for world. Therefore, it would not actually change its price in the but-for world, and consumers of this app would be no better off in Professor McFadden's but-for world. This is consistent with Professor Elhauge's testimony that developers would be unlikely to change their pricing in response to a commission change if price tiers remain in effect.[63]

60. To assess the effect of the but-for world price tier assumption on Professor McFadden's conclusions, I evaluate the but-for profitability of each Game app in Professor McFadden's analysis at three points: (1) no price change; (2) price adjusted to the next highest pricing tier; and (3) price adjusted to the next lowest pricing tier. By comparing the profitability of these apps at each price, I can determine whether each app would optimally choose not to adjust its price, adjust its price upward, or adjust its price downward in Professor McFadden's but-for world. I then compare these results to Professor McFadden's optimal price changes for each app in the but-for world.[64]

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phenomena are -- as they exist, are very – are very hard to systematize and quantify so that I think that there would be a misleading deviation from the purpose of the model, which is to find a common effect.").

[62] Workpaper 10.

[63] Deposition of Einer Elhauge, July 30, 2021 ("Elhauge Deposition"), 39:23–40:8 ("And particularly with 99-cent price tiering, which I mentioned in my report…if you combine that economics with the price tiering, it seemed to me that it's very unlikely to result in any pass-through if…the 99-cent tiering remains."), 234:3–9 ("Q. (By Mr. Swanson) Well…is the approach that Professor Economides is taking resulting in many class members losing a percentage of the damages they could prove up individually? A. So I don't think so, no. Because, as I mentioned, you know…for this case, I'm assuming the pricing tiers remain, unlike in the consumer class action. So if you assume there's still 99 cent price tiers…in a market like this, given low marginal costs, I think you would have to be a very, very expensive app, like on the order of $40 or more per app to – for a firm to, you know, want to change a pricing tier in response to a 15 percent commission change. So I think that would be very unlikely to be the case, even if you assumed that you could prove it.").

[64] This is an illustrative exercise. Professor McFadden's model is not designed to properly account for price tiers and, for example, ignores the fact that developers have set prices accounting for price tiers even in the actual

61. Exhibit 6 presents the results of this analysis. Of the 2,968 observations in Professor McFadden's analysis, he predicts lower prices in the but-for world for 2,466 (83.1 percent) observations.[65] However, I find that for 1,539 (51.9 percent) of these observations, developers would optimally choose *not* to adjust their price in the but-for world rather than adjusting their price higher or lower by one pricing tier. Only [redacted] observations [redacted] of Professor McFadden's sample find it optimal to adjust their price downward by an entire price tier in the but-for world. As such, Professor McFadden grossly overestimates how often apps would lower their prices in his but-for world—which directly leads to overestimating the number of harmed consumers. Therefore, Professor McFadden's methodology is unreliable for the determination of harm for the proposed consumer class.

EXHIBIT 6
Pricing decisions in presence of discrete pricing tiers

Predicted price change in but-for world if there are no price tier requirements (McFadden baseline)		Predicted price change in but-for world taking into account price tier requirements (new sensitivity)	Number of observations
Price falls in but-for world	↗	Price falls in but-for world	[redacted]
	↘	Price stays the same	
Price rises in but-for world	→	Price stays the same	

Source: McFadden Production; "A Better App Store Pricing Matrix," *Equinux*, January 24, 2019, available at https://www.equinux.com/us/appdevelopers/pricematrix.html, accessed on July 26, 2021.

Note: Each observation is a distinct combination of an app and year. Results are based on comparing the developers' profit in the but-for world at the actual-world price, the next higher price tier, and the next lower price tier. If the higher price is most profitable (which never occurs), the app is assumed to raise its price in the but-for world. If the lower price is most profitable, the app is assumed to lower its price in the but-for world. If the actual-world price is most profitable, the app is assumed to keep its price the same in the but-for world. These results are calculated taking the rest of Professor McFadden's methods as given.

world, as discussed above. Given the limitations of Professor McFadden's model, this was most straightforward way to evaluate the impact of price tiers on Professor McFadden's conclusions.

[65] Each observation is a distinct combination of an app and a year.

6.3. Professor McFadden incorrectly ignores competition among apps

6.3.1. Professor McFadden incorrectly assumes that developers price like monopolists

62. Professor McFadden does not model any competition between apps—even within the same genre.[66] Rather, his model assumes that apps price in a manner that completely ignores pricing decisions by other apps, no matter how similar.[67] For example, according to Professor McFadden, the demand for a baby-naming app like Lil' Baby Names will not be affected by any changes to the availability or prices of other baby-naming apps, and the developer of a baby-naming app will set download and in-app purchase prices without considering prices of competing baby-naming apps. In effect, Professor McFadden is assuming that each app sets its price as a monopolist.[68]

63. This assumption is wrong and disconnected from the actual world. Professor McFadden admitted during his deposition that, in reality, there is competition between apps, and rivals do impose limits on developers' ability to set their own prices.[69] In fact, he indirectly conceded that many apps face "pretty competitive" environments.[70] Competition occurs not only between apps that use similar business models but also between apps that use different business models,[71] including free apps, which Professor McFadden has excluded from his analysis altogether, as discussed in §6.1 above. Professor Schmalensee discusses the fact that named Developer Plaintiffs' apps Lil' Baby

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[66] While Professor McFadden never states this monopoly claim in his report, it is implicit in his modeling of demand. McFadden Report, ¶ 180.

[67] McFadden Deposition, 161:6–9 ("Q. Does the quantity of the app downloaded depend on the price of any other app? A. In this equation, as…written, it does not.").

[68] Professor McFadden does not explicitly assume or state that each app is a monopolist but because his model ignores any effect of competition on how apps set their prices, it predicts prices as if each app were a monopolist.

[69] McFadden Deposition, 83:12–24 ("Q. Do you Assume that every iOS app developer possesses monopoly power? A…if you produce a differentiated product, you have at least some local ability or market power to control the price you charge for that product. The limits of that ability will be determined by the uniqueness of the near product and the ability of rivals to attract potential customers away from you.").

[70] Professor McFadden noted that the demand elasticity tells an economist how much competition a product faces, and that elasticities of three or higher are "pretty competitive." See McFadden Deposition, 128:10–129:3 ("If the app developer faces…strong competition, that elasticity will be large. People will easily substitute away from it to rival apps…Q…And what…would be an example of an elasticity that would be consistent with a high level of competition? A…in my judgment, three is pretty competitive."). Professor McFadden estimates that 59 percent of the apps he studies had, in at least one year, an elasticity of at least three and, therefore, he would judge them to be in a "pretty competitive" environment. Workpaper 11.

[71] Raoul Kubler et al., "App Popularity: Where in the World Are Consumers Most Sensitive to Price and User Ratings?" *Journal of Marketing*, 82, 2018, pp. 20–44 at pp. 21–23 ("As in many other product categories, developers face substantial investment risks and potential returns from the strong growth, market dynamism, and competition of apps.").

names and Pure Sweat Basketball Workouts each face competition from many other iOS apps, both paid and free.[72]

64. Thus, in reality, apps on the App Store do not all price like monopolists—competition between apps can and does affect their pricing decisions. Because Professor McFadden ignores this important reality, his predictions about prices of apps in the but-for world are unreliable.

65. Professor McFadden's theoretical justification for ignoring competition between apps is also wrong. It is based on the assumption that any individual's probability of buying a particular app does not depend on any observable characteristics of that individual.[73] For example, he assumes that a younger person has the same probability of buying a racing game app as does an older person.[74] These foundational assumptions are overly simplistic, counter to reality, and therefore call into question Professor McFadden's entire approach.

6.3.2. Professor McFadden ignores that different apps face different overall levels of competition

66. As just discussed, Professor McFadden's model does not directly account for competition between apps. Competition only impacts his findings through the overall elasticity of demand that an app faces. In particular, the demand for an app that faces intense competition would have a higher elasticity of demand than another app in the same genre that does not face as much competition.[75]

67. But Professor McFadden assumes all apps within the same genre will have the same sensitivity to price.[76] This means that within a genre, all apps that

[72] Schmalensee Report, ¶ 184 ("…the named plaintiff Cameron's Lil' Baby Names app seems to face direct competition from [other paid and free apps]…Similarly, Exhibit 3 documents that a search for 'Basketball Training' on the App Store returned more than fifty free apps [plus paid options].").

[73] McFadden Report, Appendix D, ¶¶ 8–9.

[74] Furthermore, Professor McFadden's model fails to account for the fact that some individuals—even if not identified by any observable characteristics such as age—are attracted to particular *groups* of apps. For example, a person who is interested in watching television shows may be more likely to download an app that provides reviews of television shows than someone who does not like to watch a lot of television shows. Professor McFadden simply assumes that all individuals have the same probability of downloading a television show review app.

[75] McFadden Deposition, 128:10–14 ("If the app developer faces…strong competition, that elasticity will be large. People will easily substitute away from it to rival apps, and if there's not much competition for it, then that elasticity will be low.").

[76] McFadden Report, Equations (10) and (11); McFadden Deposition, 174:5–9 ("Q. Does your model assume that all apps in the same category or genre face demand functions with the same price sensitivity? A. Yes…the current model…has that form.").

have the same price face the same elasticity of demand.[77] Thus, a given app's price elasticity, which is meant to capture the level of competition an app faces, is completely unaffected by changes in the presence and prices of similar apps.

68. This is wrong and ignores an important type of difference among apps (and developers): Different apps face different levels of competition, even within a single genre, and that competition would affect developers' decisions differently. For example, consider a note-taking app that offers some advanced note-taking functionality. The developer of that app may consider the prices, business models, and features of other note-taking apps in setting its own price. If there are no other note-taking apps that offer similarly advanced functionality, the app may charge a higher price than, or use a different business model from, the other note-taking apps. On the other hand, if the functionality is similar to that offered by many apps, the apps may be constrained to choose a price and business model that is similar to that of other note-taking apps.

69. This suggests that the overall level of competition an app faces is an individualized issue, and I show this empirically below. Furthermore, it is highly relevant for Professor McFadden's but-for predictions: Apps facing more competition—apps facing more elastic demand—will pass on *more* of any decrease in commission in the but-for world. However, instead of providing a method to determine whether iOS apps will respond to changes in Apple's commission rate in a common manner, Professor McFadden simply assumes his conclusion by ignoring competition among apps altogether, and then assuming that all apps in a genre face the same price sensitivity. His methods therefore cannot show whether any individual consumer, let alone the whole class, is harmed.

70. To show that the demand for all apps within a genre do not, in fact, have the same sensitivity to price, I alter Professor McFadden's model to allow the price sensitivity parameter to be different for different apps within the same genre. In particular, I divide apps within a genre into high revenue and low revenue apps and estimate the price sensitivity parameter for these two types of apps

[77] This statement applies separately for the elasticity of demand for downloads and the elasticity of demand for in-app purchases. See Appendix F for proof. Professor McFadden incorrectly rejected this conclusion during his deposition. See McFadden Deposition, 162:1–12 ("Q…have you been able to recall…whether the elasticity [of] demand estimate you get is the same for all apps in a given genre at a given price point? A.…I think…in Equation 8 the answer is 'no,' because the…different apps with different X's will have the…same parameter alpha in different levels of Q, and I think that will produce different demand elasticities.").

separately while keeping all other assumptions made by Professor McFadden intact.[78]

71. Exhibit 4 below shows the results. I find that demand for in-app purchases for high-revenue Games exhibits more than eight times the price sensitivity as for low-revenue Games [redacted]. For Music and Entertainment, demand for in-app purchases for low-revenue apps exhibits more than four times the price sensitivity as for high-revenue apps [redacted].

72. This difference, which is masked in Professor McFadden's analysis, likely also impacts his conclusions regarding which, and how many, consumers are harmed. However, when I attempt to use Professor McFadden's model to determine but-for prices for these apps, his model fails even to predict any but-for prices.[79] This highlights how Professor McFadden's model breaks down with simple changes that better reflect reality. His model is, therefore, not capable of reliably determining which, and how many, consumers are harmed.

[78] High revenue and low revenue apps are determined by whether the app's lifetime from Professor McFadden's 0.1 percent sample were above or below the median app lifetime revenues within an app's genre and business model categories. Business model categories are determined using Professor McFadden's methodology. Apps with more than one business model were assigned to the model they used for the most months.

[79] This is because, for low-revenue Games and high-revenue Music and Entertainment apps, lower demand for downloads for an app implies higher demand for in-app purchases of an app (a -0.81 coefficient for low-revenue Games, and a -7.67 coefficient for high-revenue Music and Entertainment apps). This means that developers can earn infinite profits by charging an infinite download price; thus, these findings can neither explain the data observed in the actual world (developers set finite download prices) nor predict what developers would do in the but-for world. I discuss other results of this type in §7.2.

EXHIBIT 7
Demand estimates when price sensitivities can vary between high-revenue and low-revenue apps

	App download equation	In-app purchases equation	
	Download price	In-app purchase price	Log downloads
Baseline			
Games	[redacted]	[redacted]	[redacted]
Music and Entertainment	[redacted]	[redacted]	[redacted]
Grouped by revenue			
High-Revenue Games	[redacted]	[redacted]	[redacted]
Low-Revenue Games	[redacted]	[redacted]	[redacted]
High-Revenue Music and Entertainment	[redacted]	[redacted]	[redacted]
Low-Revenue Music and Entertainment	[redacted]	[redacted]	[redacted]

Source: McFadden Production

Note: High-Revenue and Low-Revenue apps are determined by whether the app's lifetime revenues from Professor McFadden's 0.1 percent sample were above or below the median app lifetime revenues within an app's genre and business model categories. Business model categories are determined using Professor McFadden's methodology. Apps with more than one business model were assigned to the model they used for the most months.

6.4. Professor McFadden's incorrect assumption that all in-app purchases for an app will change their prices by the same dollar amount impacts which, and how many, accounts are harmed

73. Professor McFadden states that in his model he has assumed that developers change the price of every in-app purchase item by the same amount in the but-for world.[80] What he does not explicitly state, but is implicit in the mathematical assumptions he makes, is that developers change the price of all in-app purchase items by the same *dollar* amount in the but-for world.[81] In other words an in-app purchase item of 99 cents would experience the same dollar amount price increase as one priced at $29.99. This is clearly wrong. Changing this assumption changes his conclusions regarding which, and how many, consumers are harmed.

74. This assumption also mechanically obscures an area where differences in impact are likely to arise: consumers who buy different in-app purchase items

[80] McFadden Report, Appendix E, ¶ 38.

[81] Per McFadden Report, Equation (9), the demand for in-app purchases is log-linear. So it follows from ¶ 42 of his Appendix E that but-for prices change by the same dollar amount. Contrary to what his equations imply, Professor McFadden claimed in his deposition that he assumes that but-for prices for in-app purchases change by the same *percentage* amount. See McFadden Deposition, 169:11–23. While I disagree with Professor McFadden, I also performed all the calculations in this section allowing but-for prices for in-app purchases to change by the same percentage amount, and they do not change my opinions. See Workpapers.

for the same app may suffer different amounts of harm—and some may experience no harm at all. Looking at only an average price across many in-app purchase items assumes away all such differences.

75. Let me illustrate this using an app in the Games genre, Roblox. It offers in-game currency—called Robux—in a variety of different bundle sizes, as well as a variety of subscriptions in both one- and three-month durations.[82] Prices range from $0.99 to $49.99. Professor McFadden's approach assumes that Roblox changes the price of all of these items by the same *dollar* amount in the but-for world. Hence, if Professor McFadden's model finds that Roblox's average in-app purchase price would decrease by $1.00 in the but-for world, this means both a one-month ($5.99) and three-month subscription ($15.99) would each decrease in price by $1.00. This implies a 16.7 percent price decrease for the one-month subscription and a 6.3 percent price decrease for the three-month subscription.

76. To highlight just how much this assumption affects Professor McFadden's but-for in-app purchase price predictions, I remove this assumption and allow Roblox to adjust the prices for all of its in-app purchase items separately. For this analysis, I retained all other flawed aspects of Professor McFadden's model, including his estimated demand parameters.[83] Exhibit 8 shows Professor McFadden's calculated price adjustment for each of these in-app purchase items, compared to the price adjustment that would occur if developers could adjust each item's price separately. Clearly, Professor McFadden's assumption obscures a remarkable amount of difference across the pricing of in-app purchase items that would occur in the but-for world, even assuming the rest of his model was correct (which it is not).

[82] See Exhibit 8 below.

[83] I note that his demand parameters are estimated at the app-month level, which means that even his demand estimation is affected by this simplifying assumption. I do not address this issue in my report, however.

EXHIBIT 8
Illustration of separately pricing in-app purchase items for the same app

Item	Quantity purchased	McFadden (app-level) price			Item-level price		
		Actual world	But-for world	Change	Actual world	But-for world	Change
[redacted]							

Source: McFadden Production

Note: These data represent transactions from 2018. Marginal costs and but-for prices for each item are estimated using McFadden's estimated demand and marginal cost equations from paragraph 36 in Appendix C. Otherwise, Professor McFadden's methods and estimated demand parameters are unaltered.

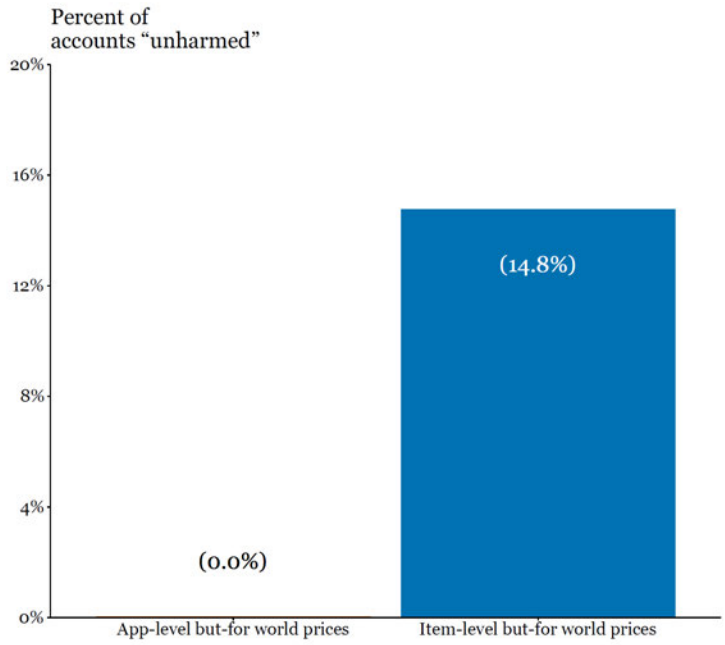
77. These different in-app purchase price changes (when not assumed away by Professor McFadden) matter. My analysis of Roblox shows that removing this assumption leads to a large shift in the number and identity of harmed accounts.

78. For this analysis, I allow only Roblox, but not other apps, to adjust prices for in-app purchase items separately (as illustrated in Exhibit 8 above). Further, I consider only those accounts in Professor McFadden's prediction sample that made a paid Roblox transaction.

79. Allowing Roblox to adjust prices for all in-app purchase items independently raises the number of accounts that Professor McFadden finds unharmed from 0 percent to 14.8 percent.[84] Exhibit 9 demonstrates these results.

[84] These numbers assume that each in-app purchase item for the same app changes price by the same dollar amount. I have computed alternative numbers assuming that each in-app purchase item for the same app changes price by the same percentage amount. The findings are qualitatively similar and even stronger. Workpaper 12.

EXHIBIT 9
Number of unharmed Roblox consumers when item-level prices are used in the but-for world



Source: McFadden Production

Note: These results apply Professor McFadden's methods exactly, except that they allow Roblox to set but-for world prices for each in-app purchase item separately. The analysis only considers accounts that made a paid Roblox transaction. The orange bar provides a comparison to Professor McFadden's original results.

80. As shown in Appendix Exhibit 4 in Appendix E, which consumers are harmed also changes when Roblox is allowed to set prices for different in-app purchase items independently. Almost 15 percent of accounts in Professor McFadden's sample change from harmed to unharmed, or vice-versa, when this assumption is changed.

81. Therefore, changing Professor McFadden's assumption—that developers adjust the prices of all in-app purchase items for the same app by the same amount[85]—has a profound impact on which, and how many, accounts he finds are harmed. This means that his approach is not reliable for this purpose.

[85] McFadden Report, Appendix E, ¶¶ 42–45.

6.5. Professor McFadden's marginal cost estimates defy market realities

82. Professor McFadden's failure to estimate marginal costs that reflect observed market realities renders his entire model unreliable and flawed. While any model, no matter how sophisticated, will fail to match certain facts about the world, marginal costs are one of the key drivers of Professor McFadden's results.[86] Therefore, it is important that Professor McFadden estimate marginal costs correctly. He has not.

83. The academic literature, plus evidence in this matter and *Epic v. Apple*, show that many software and online services in general—and iOS apps in particular—are likely to have zero or close to zero marginal costs.

- In their research on digital goods, Anja Lambrecht et al. (2014) state that "[Digital products] have near zero marginal cost of production and distribution even over large distances."[87] Similarly, Goldfarb and Tucker (2019) state that "Digital goods can be replicated at zero cost."[88]
- In his testimony at the *Epic* trial, Epic CEO Tim Sweeney attested that the in-game currency for Fortnite, V-Bucks, "has no marginal cost."[89]
- Epic's expert Dr. David Evans agreed with this statement in his testimony in the same trial.[90]
- In his deposition, Professor Einer Elhauge testified that marginal costs for Apple developers are generally "very small."[91]

84. Professor McFadden estimates marginal costs that are too high to be consistent with this evidence. In general, he estimates the median marginal cost for paid download only apps in the Games genre is [redacted] (as compared to a

[86] In Professor McFadden's model, marginal costs are inextricably linked to demand elasticities, one of the other key drivers of his results. See Appendix D.

[87] Anja Lambrecht et al., "How Do Firms Make Money Selling Digital Goods Online?" *Mark Lett*, 25(3), 2014, pp. 331–341 at p. 332–3 ("[Digital products] have near zero marginal cost of production and distribution even over large distances.").

[88] Avi Goldfarb and Catherine Tucker, "Digital Economics," *Journal of Economic Literature*, 57(1), 2019, pp. 3–43 at p. 3.

[89] Trial Testimony of Mr. Timothy Sweeney, *Epic Games, Inc. vs. Apple, Inc.*, May 3, 2021, at 190:12–16 ("Q.What does it cost to Epic to generate a V-Buck, minting a V-Buck? A. There is no cost to a V-Buck. There's cost in developing the software, but the V-Bucks themselves don't have a marginal cost.").

[90] Trial Testimony of Dr. David Evans, *Epic Games, Inc. vs. Apple, Inc.*, May 11, 2021, at 1426:12–1427:12 ("Q. You heard Mr. Sweeney testify that V-Bucks have no marginal cost, didn't you? A. The currency has no marginal cost. Q. I'm sorry? A. The currency has no marginal cost. […] Q. So your testimony is not in reliance on anything -- any of the evidence that has been received orally in the court since the first day of the trial, correct? A. Yeah, I think that's correct. Q. Now, you agree with Mr. Sweeney that there's no marginal cost for V-Bucks? A. I do.").

[91] Elhauge Deposition, 40:9–12 ("Q. (By Mr. Swanson) Is it your opinion personally that marginal costs for Apple developers are very small? A. Yes, generally, yes.").

median price of [redacted]) and in the Music and Entertainment genres is [redacted] (as compared to a median price of [redacted]).[92] Similarly, he estimates that the median marginal cost for in-app purchase items for free download in-app purchase apps in the Games genre is [redacted] (as compared to a median price of [redacted]) and in the Music and Entertainment genre is [redacted] (as compared to a median price of [redacted]).[93] In fact, for 90.6 percent of Games apps and [redacted] percent of Music and Entertainment apps he considers, Professor McFadden finds positive marginal costs,[94] and he finds that 25 percent of Games that are free with in-app purchases have marginal costs that exceed [redacted].[95]

85. Indeed, some of Professor McFadden's marginal cost estimates are implausible on their face. For instance, he estimates that Fortnite in-app purchase transactions had a marginal cost of $20.05 in 2018, or a 37.4 percent profit margin, which is inconsistent with the trial testimony described above.[96] Similarly, he estimates that another game, Final Fantasy XV: A New Empire, had marginal costs for in-app purchases between $64.33 in 2017 and $55.40 in 2019,[97] and that music app LivePhish had marginal costs for in-app purchases between $31.77 in 2016 and $66.15 in 2019.[98] A model that estimates such unrealistically high marginal costs for an incremental in-app purchase is unreliable.

86. This overestimation of marginal costs has a direct effect on Professor McFadden's class-wide impact results. Apps that have zero, or negative, marginal costs likely will not lower their prices in response to a change in Apple's commission in the but-for world. As Professor McFadden agrees, consumers that purchase some apps whose price would fall in the but-for world, and some apps whose price would rise, may not be harmed.[99] Therefore,

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[92] McFadden Report, Figures 28 and 29.

[93] McFadden Report, Figures 28 and 29.

[94] Across Games, Music, and Entertainment apps that Professor McFadden considers, he finds that [redacted] have positive marginal costs. This is the fraction of apps that ever had positive marginal costs; the fraction of app-year combinations that had positive marginal costs was [redacted]. Workpaper 13.

[95] Workpaper 14.

[96] Workpaper 15.

[97] Workpaper 16.

[98] Workpaper 16.

[99] McFadden Deposition, 201:22–202:3 ("Q. Okay. So you agree that if a consumer spent money on an app whose but-for price is lower than [and] another app whose but-for price is higher, the net harm of Apple's conduct would need to account for both those price changes; is that right? A. Yes, that's the way I do it, and I think that's economically appropriate. Q. And if the net is…positive, then the consumer has not been harmed, correct? A. That would be correct, yes.").

Professor McFadden's underestimation of apps with zero marginal costs leads to an underestimation of the number of unharmed consumers.

87. Overestimation is not the only way in which Professor McFadden's marginal cost estimates are unreliable. His estimates are also unrealistically uniform. Professor McFadden finds, for instance, that every single one of the 62 Games apps in his Paid Download sample[100] that had a download price of $1.99 faced marginal costs between [redacted] and [redacted]—a [redacted] range.[101] As a result, he calculates that these apps all have near-identical profit margins.

88. Furthermore, Professor McFadden also implausibly finds that the most expensive apps within each genre and business model tend to have the lowest profit margins.[102] Professor McFadden has offered no evidence that such outcomes are consistent with market realities.

89. In short, Professor McFadden has failed to verify that one of the most crucial outputs of his model is realistic. Even basic inspection shows otherwise.[103]

7. ARBITRARY CONSTRAINTS, NOT CONSUMER BEHAVIOR, DRIVE PROFESSOR MCFADDEN'S RESULTS

90. Professor McFadden puts constraints on his model that directly drive his most important results. In particular, he imposes ad hoc constraints on the level of consumers' price sensitivity, and therefore apps' elasticity of demand. Professor McFadden supposedly does this to ensure that apps' profit margins are reasonable. But it effectively means that he selects his estimate of price sensitivity. This means Professor McFadden has assumed his conclusion, and his methodology cannot reliably be used to estimate but-for world prices and

[100] Download prices within 1 cent of 1.99 were considered. 138 app-year combinations meet this criteria, covering 62 apps. Of these 138, 40 had an in-app purchase transaction *outside* Professor McFadden's 0.1 percent sample, and therefore were misclassified by Professor McFadden. Workpaper 17. I discuss other aspects of this issue—that his small sample cane lead him to make incorrect inferences about an app—in §7.

[101] Workpaper 17.

[102] See Appendix F for proof. [redacted] Meanwhile, he finds that Eden World Builder, a game similar to Minecraft but with $1.9 million in revenue from downloads between 2010 and 2019 at an average download price of $0.94, has an average profit margin of 148 percent. Workpaper 18.

[103] I reserve the right to comment if Professor McFadden presents additional analysis.

therefore identify consumer harm for any member of the proposed Consumer Class.[104]

7.1. Professor McFadden's model is unreliable because ad hoc constraints drive results

91. In Professor McFadden's approach, developers of apps with sufficiently low elasticity of demand, or sufficiently low marginal costs, increase their prices to consumers in the but-for world.[105] This makes it critical for Professor McFadden to reliably estimate each app's elasticity of demand and marginal cost in order to determine which consumers are harmed. However, he does not make full use of the rich app transaction data he has available to estimate demand elasticities faced by developers, nor does he use data from more than a handful of developers to shed light on developers' actual marginal costs.[106] Instead, he imposes a litany of assumptions that drive his estimated elasticities of demand and inferred marginal costs. One such assumption, which I focus on in this section, is to impose *ad hoc* constraints.[107]

92. To calculate each app's demand elasticity, Professor McFadden needs to estimate consumers' price sensitivity. Professor McFadden purports to use the underlying Apple data to do so by measuring the relationship between app download and in-app purchase prices on the one hand, and purchases of apps and in-app purchase made by consumers (i.e., quantities) on the other. However, the actual data on prices and quantities plays a limited role in determining his estimates of price sensitivities. This is because Professor McFadden places bounds, *ex ante*, on the result that he will obtain when

[104] Furthermore, his methodology of imposing a margin constraint based on accounting information from a handful of firms is inconsistent with well-established literature. The literature typically relies on a properly estimated demand function *without* margin constraints, then recovering the implied marginal costs, and finally using information on actual costs (if available) to *validate* the underlying model. See, e.g., Aviv Nevo, "Measuring Market Power in the Ready-to-Eat Cereal Industry," *Econometrica*, 69(2), 2001, pp. 307–342. In §6.5, I show that the marginal costs Professor McFadden recovers are, in fact, inconsistent with actual costs, further invalidating his model. The three papers he cites (see McFadden Report, n. 291 purportedly to justify his approach do nothing of the sort and instead use altogether different types of constraints in unrelated contexts.

[105] This result follows from the equations for the but-for world prices in McFadden Report, Appendix E, ¶¶ 41–42. See Appendix F for a more detailed explanation.

[106] Data from specific developers are only used to inform the bounds of the margins constraints, as described in McFadden Report, Appendix E, ¶¶ 32–34.

[107] The quantity Professor McFadden directly estimates is a "price coefficient"—the slope of the demand curve, which he assumes is the same across all apps in a genre (an issue I discuss in §6.3). However, this constant quantity is directly related to each app's demand elasticity by the following equation: Demand elasticity = (Price coefficient) × Price.

estimating consumer price sensitivity; that is, he assumes that the result will lie in a specific range.[108]

93. I can show empirically that Professor McFadden's estimates of consumers' price sensitivity are driven by assumption (i.e., by the *ad hoc* constraints he imposes), and not in fact by the observed relationship in the data between quantities and prices. If the estimated price sensitivity were being driven by the observed relationship in the data, one would expect that changing the underlying data on quantities would change the estimated price sensitivity. But I implemented this test, and found that Professor McFadden's method fails.

94. In particular, I ran his demand estimation on hypothetical data that substitutes random "placebo" quantities for actual quantities. I obtain precisely the same values for three of the four price sensitivity estimates.[109] It is therefore apparent how divorced Professor McFadden's estimates are from the transaction data on which they should be primarily based.

95. As a separate exercise, I test whether Professor McFadden's price sensitivity estimates are sensitive to the specific constraints he imposes. Professor McFadden said during his deposition that he expects the analysis would give "roughly similar results" with different bounds.[110] However, this is not the case. I find that when I change his bounds, but make no other changes to his methods, his results also change substantially. The detailed results are shown in Exhibits 6 and 7 in Appendix G.

96. Thus, when Professor McFadden selects the bounds to impose, he is indirectly selecting his estimate of price sensitivity, and therefore, each app's demand elasticity. In other words, via his imposed constraints, he is assuming the conclusion within his demand model. This renders his demand elasticity estimates unreliable. And given the central role these estimates play, this means that his model cannot be reliably used to identify harm for any member of the proposed Consumer Class.

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[108] McFadden Report, ¶ 213.

[109] In particular, I draw random integer numbers from 1 to 1000 for quantities of app downloads and in-app purchase transactions. Workpaper 19.

[110] McFadden Deposition, 184:1–10 ("Q. Have you evaluated to what extent, if any, your demand estimates are driven by your supplemental cost data as opposed to the observed relationships between price and quantity? A. Yes, I do have a sense of that, and…their influence is not zero. But much…of the analysis would be similar and…give roughly similar results with…different bounds drawn…from the…cost data for this limited number of developers.").

7.2. Professor McFadden calculates his margin constraints incorrectly

97. I have shown that Professor McFadden applies *ad hoc* constraints on average profit margins, which drive his consumer price sensitivity estimates, and therefore, his estimates of demand elasticity for each app. In this section, I also show that the specific constraints he imposes regarding profit margins are incorrect and without economic basis for at least three reasons. Because these imposed constraints ultimately determine his prediction of but-for app and in-app purchase prices, his method is unable to identify how many and which consumers are harmed.

98. First, the developers whose cost data Professor McFadden has analyzed (his "benchmark firms")—namely, Epic, Playtika, Pocket Gems, Spotify, Pandora, and Netflix[111]—are not representative of the apps for which Professor McFadden estimates demand elasticities. He offers no evidence of their representativeness and, in fact, does not even state how he selected the firms, beyond that they "have produced cost data."[112] At his deposition, when asked about whether he had any evidence that these firms are representative, he admitted they are "weighted to public companies and…Epic," and acknowledged that it "would be useful to have more developer data."[113] Indeed, they are not representative; Professor McFadden noted in his deposition that they "are all substantial developers with substantial revenue, so they are at the upper end,"[114] so they may have very different cost structures from smaller developers.

99. Second, Professor McFadden's constraints are based on apples-to-oranges comparisons. Professor McFadden calculates profit margins for his benchmark firms as unified entities, rather than specifically for their iOS business or each iOS app.[115] However, in his constraints, he compares the profit margins of iOS

[111] McFadden Report, ¶¶ 189–195

[112] McFadden Report, ¶ 212.

[113] McFadden Deposition, 188:1–7.

[114] McFadden Deposition, 188:13–15.

[115] Two of his benchmark firms, Spotify and Netflix, do not even monetize on the App Store currently, instead taking advantage of the reader rule. Thus, whatever profit margins Professor McFadden computes for them almost entirely reflect revenue earned *outside* the App Store. See App Store Review Guidelines, 3.1.3(a) ("'Reader' Apps: Apps may allow a user to access previously purchased content or content subscriptions (specifically: magazines, newspapers, books, audio, music, and video)."); Chris Welch, "Netflix stops offering in-app subscriptions for new and returning customers on iOS," *The Verge*, December 28, 2018, available at https://www.theverge.com/2018/12/28/18159373/netflix-in-app-subscriptions-iphone-ipad-ios-apple, accessed on July 31, 2021 ("Now, customers will have to begin a subscription through a web browser such as Safari…Spotify, the leading subscription music app, has also bypassed Apple's in-app billing for similar reasons.").

apps in particular—dividing the iOS price, less marginal cost, by the iOS price—rather than the firm as a whole.[116]

100. Third, Professor McFadden underestimates his benchmark firms' profit margins by first assuming that marginal costs are equal to average variable costs, and then incorrectly assuming that all user acquisition costs for some of his benchmark firms are variable costs.[117] An example of user acquisition costs is advertising costs; there is no reason to believe that all user acquisition costs are variable.Variable costs are costs that change because of a change in level of output. It is not true that an app developer incurs additional user acquisition costs every time a consumer chooses to download their app. Rather, the causation could run the other way around; when an app developer incurs additional user acquisition costs, more consumers will choose to download their app.

101. To support classifying all user acquisition costs as variable, Professor McFadden shows that—for a single developer, Pocket Gems—user acquisition costs are correlated with revenue.[118] He does not offer any explanation of why this pattern implies that user acquisition costs are variable.[119] However, he seems to be arguing that the observed correlation between revenue and user acquisition costs implies that an increase in revenue causes an increase in user acquisition costs. This would in turn imply that user acquisition costs are indeed variable, but this logic is wrong for two reasons. First, this pattern would also be expected from the reverse causation I just discussed—i.e., if additional user acquisition costs lead to increased revenue, rather than vice-versa. Second, he has only performed this analysis for one firm. [redacted]

[116] McFadden Report, Appendix E, ¶ 33. The inappropriateness of the comparison is epitomized by the negative marginal costs Professor McFadden estimates that imply profit margins of over 100%. He suggests that this may result from other revenue streams for a paid app download, aside from the paid download itself (e.g., advertising). Note that this could never happen for his benchmark profit margins; he is considering the firm as a whole, which means there can be no "other revenue streams," and he is therefore guaranteed to find a profit margin of no more than 100 percent.

[117] McFadden Report, ¶¶ 189–195, 197.

[118] McFadden Report, ¶ 198.

[119] McFadden Report, ¶198.

EXHIBIT 10

[redacted]

Source: [redacted] tabs "9d" and "9e"
Note: [redacted]

102. Thus, the specific values Professor McFadden uses for his constraints are unsupported and incorrect, even ignoring other problems with these constraints.

7.3. Removing Professor McFadden's arbitrary constraints more than doubles the number of unharmed accounts

103. Because these incorrect *ad hoc* constraints assume Professor McFadden's conclusion and make his methodology unreliable, I have estimated Professor McFadden's model without these constraints, making no other adjustments. In Exhibit 11, I show how the estimated demand parameters compare to Professor McFadden's. When the constraints are removed, Professor McFadden's demand estimation method finds that consumers are far less sensitive to download prices. The estimated app download price sensitivity changes [redacted] for Games apps, while for Music and Entertainment categories it changes [redacted].

EXHIBIT 11
Demand estimates with no profit margin constraint

		App download equation	In-app purchases equation	
		Download price	In-app purchase price	Log downloads
With profit margin constraints				
Games	Coefficient	[redacted]	[redacted]	[redacted]
Music and entertainment	Coefficient	[redacted]	[redacted]	[redacted]
Without profit margin constraints				
Games	Coefficient	[redacted]	[redacted]	[redacted]
	95% Confidence Interval	[redacted]	[redacted]	[redacted]
Music and entertainment	Coefficient	[redacted]	[redacted]	[redacted]
	95% Confidence Interval	[redacted]	[redacted]	[redacted]

Source: McFadden Production

Note: These estimated demand coefficients apply Professor McFadden's methods exactly, except that they remove his profit margin constraints. The results in the first panel are Professor McFadden's, and match those in Figure 15 in his report. The results in the second panel are those from the adjusted implementation. 95% confidence intervals are constructed based on the estimates obtained using Professor McFadden's sampled bootstrap data sets.

104. In addition, without his constraints, Professor McFadden's model fails to precisely estimate the demand for in-app purchases, also shown in Exhibit 10. The in-app purchase price sensitivity for Games, for example, has a very wide confidence interval between -27.14 and 6.42, indicating the true price sensitivity might realistically be anywhere within this range.[120]

105. In Exhibit 12, I show that when Professor McFadden's *ad hoc* constraints are removed, the number of unharmed accounts more than doubles—from [redacted][121]

[120] A 95% confidence interval of the price sensitivity estimate means that 95% of the time we obtain this result, the true price sensitivity falls within this interval. James H. Stock and Mark W. Watson, "*Introduction to Econometrics*," (Upper Saddle River, NJ: Pearson, 2015) at p. 80 ("Because of random sampling error, it is impossible to learn the exact value of the population mean of Y using only the information of the sample. However, it is possible to use data from a random sample to construct a set of values that contains the true population mean μ_y with a certain prespecified probability. Such a set is called a confidence set, and the prespecified probability that μ_y is contained in this set is called the confidence level. The confidence set for μ_y turns out to be all possible values of the mean between a lower and an upper limit, so that the confidence set is an interval, called a confidence interval.").

[121] These numbers assume that each in-app purchase item for the same app changes price by the same dollar amount. I have computed alternative numbers assuming that each in-app purchase item for the same app changes price by the same percentage amount. The findings are qualitatively similar and even stronger. Workpaper 20. This analysis accounts for all transactions in the full App Store database through the present.

EXHIBIT 12
"Harmed" consumers with no profit margin constraint on estimated demand

Source: McFadden Production
Note: These results apply Professor McFadden's methods exactly, except that they remove his profit margin constraints. The orange bar provides a comparison to Professor McFadden's original results.

As shown in Exhibit 5 in Appendix E, which consumers are harmed also changes when Professor McFadden's *ad hoc* constraints are removed. Over [redacted] percent of accounts in Professor McFadden's sample change from harmed to unharmed, or vice-versa, when the constraints are removed.

106. Since Professor McFadden's conclusions depend strongly on his assumed constraints regarding profit margins, which are inappropriate and incorrect, his methods are unreliable for establishing which consumers are harmed, and to what extent.

8. PROFESSOR MCFADDEN'S CONCLUSIONS BASED ON A SMALL SAMPLE OF ACCOUNTS AND APPS ARE NOT GENERALIZABLE

107. Professor McFadden estimates his model on a 0.1 percent random sample of all Apple IDs—or fewer than [redacted] out of more than [redacted] total IDs, and fewer than [redacted] out of more than [redacted] with paid transactions.[122] He further restricts his sample by modeling prices for only 1,806 high-revenue apps in the Games, Music, and Entertainment genres.[123] Professor McFadden claims that he can generalize his results from this extremely small sample of accounts and apps to characterize harm and calculate damages for the entire proposed Consumer Class.[124] Professor McFadden is wrong. I estimate Professor McFadden's model on different 0.1 percent random samples and for other genres and find that his model generates different results or fails altogether. Therefore, Professor McFadden's conclusions cannot be reliably generalized from his small sample of accounts and apps to the proposed consumer class.

8.1. Professor McFadden's methodology for sampling accounts and selecting apps

108. The App Store transactions data has transactions for more than [redacted] accounts and over [redacted] apps (out of which almost [redacted] have paid transactions). Professor McFadden studies only a small fraction of these accounts and apps. He takes the following steps to sample accounts and select apps for his analysis:[125]

[122] McFadden Report, ¶ 218. Workpaper 2. This analysis accounts for all transactions in the full App Store database through the present.

[123] McFadden Report, ¶ 229; Appendix E, ¶ 24. These three genres have 78,509 apps with a paid transaction in Professor McFadden's 0.1 percent sample, and 511,898 apps with a paid transaction in the App Store overall. Workpaper 21. This analysis accounts for transactions in the original App Store transactions data, ending on September 30, 2019.

[124] McFadden Report, ¶¶ 221.

[125] For simplicity, I have ignored certain technical steps that affect few observations, e.g., the identification and removal of returns.

a. Professor McFadden draws a random sample of 0.1 percent of all Apple IDs (accounts), which results in fewer than [redacted] accounts out of more than [redacted] total accounts in the transactions data.[126] This reduces the number of apps under consideration from over [redacted] to just under [redacted].[127]

b. He then filters to apps in the Games, Music, and Entertainment genres, which reduces the number of apps under consideration to [redacted].[128] Further limiting to apps with paid transactions within these genres reduces the number of apps to [redacted].

c. Professor McFadden then considers only the highest-revenue apps in these genres that account for [redacted] of revenue.[129] This reduces the number of apps under consideration to just 1,926.[130] He applies a few other criteria such as removing apps with download prices that change within a year, which limits the number of apps to 1,806.[131]

109. Therefore, for his analysis Professor McFadden uses data from only [redacted] accounts on the App Store to estimate elasticity of demand, marginal costs, and but-for world prices for only 1,806 apps. He then uses the changes in price for only these 1,806 apps to determine which of these [redacted] accounts are harmed.

8.2. Using a different sample changes conclusions regarding how many, and which, accounts are harmed

110. A sound methodology applied to a properly drawn and large enough random sample should yield similar results with different random samples. Professor McFadden's approach does not pass this test. His results regarding

[126] Workpaper 2. This analysis accounts for all transactions in the full App Store database through the present.

[127] Workpapers 1, 2. This analysis accounts for all transactions in the full App Store database through the present.

[128] McFadden Report, ¶ 229. He uses data from other genres only as control variables to inform his estimation for these three genres. Workpaper 21. This analysis accounts for transactions in the original App Store transactions data, ending on September 30, 2019.

[129] McFadden Report, n. 297. As he describes there, Professor McFadden sorts apps in each category (Games, or Music and Entertainment combined) and year descending by revenue in that year. Then he determines, again from each category and year, how many apps are necessary to account for the top 70 percent of revenue. Finally, he keeps an app in all years if it made the top 70 percent of revenue in any year.

[130] Workpaper 21. This analysis accounts for transactions in the original App Store transactions data, ending on September 30, 2019.

[131] McFadden Report, Appendix E, ¶ 27.

which, and how many, accounts are harmed change dramatically across different random samples. These results illustrate that either Professor McFadden's entire approach is unreliable, or he uses that approach on woefully insufficient data to generate reliable results, or both.

111. One consequence of using a small sample of available data is that Professor McFadden relies on transactions for only 1,806 apps out of almost [redacted] apps with paid transactions. Even for the apps that he considers, he measures prices and quantities inaccurately, which are critical inputs into his model. For example, Professor McFadden inaccurately measures the average in-app price for *Pure Sweat Basketball Workouts*—one of the named Developer Plaintiffs' apps. Based on a single transaction observed in his small sample, Professor McFadden incorrectly assigns an average in-app purchase price of [redacted] to *Pure Sweat Basketball Workouts*.[132] However, in the full Apple App Store Transactions data, more than [redacted] percent of all in-app purchase transactions for *Pure Sweat Basketball Workouts* are at a price of [redacted], which means that the average price is substantially lower than [redacted].[133]

112. If Professor McFadden's sampling approach and overall methodology were sound, and his sample size were large enough, then errors like the ones just described would not be large or prevalent enough to materially affect his results on harm and harmed accounts. In other words, a different random sample, or using the entire data, would not change his conclusions. Professor McFadden confirmed this when he said it would be "shocking" if his model produced results that varied in an "economically or legally significant" way on a different, randomly drawn 0.1 percent sample.[134]

[132] McFadden Report, Appendix E, ¶ 23. Workpaper 22. This analysis accounts for transactions in the original App Store transactions data, ending on September 30, 2019.

[133] Workpaper 22. This analysis accounts for transactions in the original App Store transactions data, ending on September 30, 2019.

[134] McFadden Deposition, 211:16–212:3. See also McFadden Deposition, 190:24–191:2 ("Q. So is it your expectation that if you ran your model on multiple randomly drawn samples, that the results would not be materially different? A. That's correct."). In fact, Professor McFadden goes so far as to state that if this were not the case, it would call into question Apple's ID hashing algorithm. McFadden Deposition, 190:3–12 ("If you did that and got materially different results, would that lead you to question the reliability of your original sample? A. the original sample was impeccably drawn on the basis of Apple Store's hexadecimal identification of accounts, so there should be absolutely no defection in the statistical sample. So if there were material differences, it would raise the question as to whether the Apple Store representation of their coding is correct.").

113. However, Professor McFadden's methodology and sample are indeed unreliable by this standard. I have tested Professor McFadden's model on 25 alternative, randomly drawn 0.1 percent samples of Apple IDs, and I find just the opposite: Different randomly drawn samples do lead to a wide range of different end results that vary, sometimes dramatically, from Professor McFadden's reported results.

114. First, Professor McFadden's model fails altogether on nine of these 25 samples (or 36 percent).[135] In particular, for these nine samples, Professor McFadden's model produces economically incoherent results: It predicts that an app's quantity of in-app purchases increases—without bound—when the same app's quantity of downloads decreases (holding fixed the in-app purchase price). Therefore, developers can earn infinite profit by setting infinitely high download prices, which pushes downloads toward zero, which in turn pushes up in-app purchases indefinitely. Such infinite pricing is obviously counter to what is observed in the actual world. The fact that Professor McFadden's model fails altogether for 36 percent of random samples means that it is fundamentally flawed and unreliable.[136]

115. Second, in the other 16 of these samples, the percentage of accounts that Professor McFadden's model finds unharmed varies from 5.5 percent to 12.7 percent. In other words, one of these samples produces an estimate of unharmed accounts that is more than double the estimate that another sample produces, and more than 60 percent higher than what Professor McFadden estimates. Furthermore, the same account may be harmed in Professor McFadden's analysis but unharmed when using a different sample, or vice-versa.[137] Such dramatically different results for different random samples illustrate that either Professor McFadden's entire approach is unreliable, or he uses that approach on insufficient data to generate reliable results, or both.[138]

[135] Workpaper 23. This analysis accounts for transactions in the original App Store transactions data, ending on September 30, 2019.

[136] Professor McFadden's model is predicated upon profit-maximization by developers. If his model estimates parameter values that mean that the data are not consistent with profit maximization by developers, those results are not reliable. McFadden Report, ¶ 171; McFadden Deposition, 84:23–25 ("I assume that each developer has the ability to set their price with the objective of maximizing their profit.").

[137] Workpaper 23. This analysis accounts for transactions in the original App Store transactions data, ending on September 30, 2019.

[138] To be clear, this high degree of variability means that the approach is unreliable *even if* the sample is unbiased. Simply switching from one unbiased sample to another causes too wide of a variation in the ultimate results.

8.3. Professor McFadden's model cannot predict but-for prices for almost all apps in the App Store

116. Professor McFadden's analysis is focused on only 1,806 apps in three genres out of almost [redacted] apps that generate commissions in the App Store, which means that he offers no prediction of but-for prices for more than 99 percent of apps. Not only does Professor McFadden fail to offer a prediction for most apps, his model breaks down when extended to apps in other genres. To determine harm and damages for a consumer, one must be able to predict but-for world prices for all of their purchases across all apps, which Professor McFadden's model does not and cannot do.

117. As discussed in §8.1 above, Professor McFadden limits the apps he studies in two important ways: First, he limits his analysis to Games, Music, and Entertainment apps. These three genres of course represent only a subset of all apps in Plaintiffs' alleged market and exclude important genres like Lifestyle, Photo & Video, and Business. Second, he analyzes only the apps that comprise the top 70 percent of revenue in each genre and year. The end result is a set of only 1,806 apps—less than [redacted] percent of the [redacted] paid apps in the App Store database that generate commissions, and less than three percent of the [redacted] apps in his chosen genres that generate commissions from his 0.1 percent sample of accounts.[139]

[139] Workpaper 21. This analysis accounts for transactions in the original App Store transactions data, ending on September 30, 2019. Professor McFadden claims that it would be straightforward to use the results on these apps to "scale up" the harm estimate, and to project but-for world prices for the apps he does not study, so long as they are within his chosen genres. See McFadden Report, ¶¶ 221–224; McFadden Deposition, 210:19–211:8 ("Q…Well, if your…1/10th-of-a-percent sample is not perfectly representative, you would not know exactly who the uninjured members of the class are, would you?…THE DEPONENT: The sample would not be used for the damage analysis and calculations. It was used for…the purposes of [tractability] in…the econometric estimation. The model, once estimated, can be applied to the entire database and, with procedures that are described in…the report, scaled up from the 70 percent of apps to all apps. So…there are straightforward relatively mechanical procedures for filling in these steps."). However, he has not performed this analysis and cannot know what effect it will have on the number of unharmed consumers. I reserve the right to comment on any new analysis Professor McFadden performs.

118. While these studied apps account for between 70 and 81 percent of the total App Store revenue in each genre,[140] they are insufficient for determining which accounts are harmed. As I discuss above in §4, Professor McFadden's model finds that some apps raise their prices in the but-for world.[141] It is thus critical that Professor McFadden estimate a price change for every app and in-app purchase made by an account in order to determine whether the account is harmed. Yet, Professor McFadden only estimates a price change for less than 1 percent of all non-free apps and less than 56 percent of all paid transactions in his 0.1 percent sample.[142] Over three quarters of the accounts in Professor McFadden's 0.1 percent sample make a (paid) transaction for an app that Professor McFadden excludes from his analysis.[143] Therefore, Professor McFadden cannot correctly determine whether these accounts are harmed.

119. Furthermore, focusing on such a limited collection of apps means Professor McFadden offers no assessment of harm for many accounts. Almost 10 percent of the accounts in his sample make (paid) transactions only for apps that Professor McFadden excludes from his analysis.[144] For these accounts, Professor McFadden offers no assessment whatsoever regarding whether they are harmed. This shortcoming applies even to the named Consumer Plaintiffs.[145] Of the four Consumer Plaintiffs, Professor McFadden fails to offer any harm determination for two, as they did not purchase any apps for which Professor McFadden predicted a but-for world price.[146]

[140] Workpaper 24. This analysis accounts for transactions in the original App Store transactions data, ending on September 30, 2019.

[141] McFadden Report, ¶ 225.

[142] Workpaper 25.

[143] Workpaper 26.

[144] Workpaper 27. This analysis accounts for transactions in the original App Store transactions data, ending on September 30, 2019.

[145] For reasons discussed in §4.2, one cannot link these to accounts and cannot know whether they are part of Professor McFadden's sample.

[146] Workpaper 28. Lawrence purchased an app—The Civil War Today—for which Professor McFadden predicted a but-for world price. However, Lawrence purchased the app in 2012, and Professor McFadden only predicts a but-for price for the app in 2014 and 2016. All of Professor McFadden's predictions are year-specific. Workpaper 29.

120. Professor McFadden's model cannot even be readily extended to offer an assessment of harm for many apps that he excludes. To see why, consider the Sports genre—the genre to which Developer Plaintiff's app *Pure Sweat Basketball Workouts* belongs. As mentioned earlier, Professor McFadden limits his analysis to only three genres: Games, Music and Entertainment.[147] While Professor McFadden does not use his model to provide any but-for world predictions for apps in the Sports genre, or even offer a description of how one might do so, I applied his approach to the Sports genre.[148] However, I found that his model fails to generate any predictions for the but-for world. When applied to the Sports genre, Professor McFadden's method estimates an upward sloping demand curve for in-app purchases.[149] In other words, Professor McFadden's demand estimation method predicts that consumers will engage in more in-app purchase transactions in the Sports genre if the prices of those transactions rises. This result is erroneous, as it defies economic theory and common sense.[150]

121. Furthermore, the result makes it impossible to proceed with the rest of Professor McFadden's method, because it is fundamentally incompatible with the observed data in the actual world: If demand increases with an increase in prices, then developers will maximize profits by setting an infinitely high price, which is not what developers actually do in the data.

122. I further explored this phenomenon by applying Professor McFadden's method to the Music and Entertainment genres separately rather than combined. Professor McFadden combines these two genres together, but does not offer a reason why.[151] For the Entertainment genre, Professor McFadden's approach once again fails completely: His model finds that, holding prices constant, demand for a given app's in-app purchase items goes up when downloads of that same app go down. This result is erroneous and contrary to

[147] McFadden Report, ¶ 229.

[148] In order to do so, I had to remove his constraints on the average profit margins because he did not offer a common method for determining which bounds to impose for other genres (even leaving aside the many problems with these constraints that I discuss in §8). Furthermore, Professor McFadden uses different varaibles as instruments when he estimates demand for Games and Music and Entertainment, though he does not explain why. For this exercise, I have selected the variables that Professor McFadden uses in his Games estimation.

[149] Workpaper 30.

[150] "Almost all demand curves slope downward. Intuitively, we know that when the price is higher, buying a product is less attractive than when the price is lower. As a result, some potential purchasers will decide to spend their money on other products." B. Douglas Bernheim and Michael D. Whinston, "*Microeconomics*," (New York, NY: McGraw-Hill/Irwin, 2008) at p. 27.

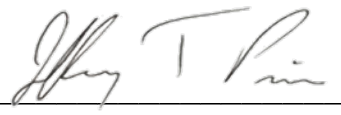
[151] McFadden Report, ¶ 229. In this case, I was not forced to drop Professor McFadden's profit margin constraints, but rather applied them as is, to each genre separately.

economic theory and common sense—consumers must download an app before engaging in in-app purchase transactions for that app. And once again, the result makes it impossible to proceed with the rest of Professor McFadden's method, because it is fundamentally incompatible with the observed data in the actual world.[152] Thus, it is clear that Professor McFadden's approach cannot be readily extended to other genres—or even to his own genres, analyzed separately.

123. In summary, Professor McFadden excludes almost all apps from his analysis, rendering it incapable of determining which consumers are harmed. Contrary to Professor McFadden's claims, simply "repeat[ing] on a larger sample" will not solve the problem.[153] The focus on only three genres (and combining two of those genres) underscores this issue: Extending the model in a straightforward way to another genre, or separating the two combined genres, causes the model to fail. Thus, individualized inquiry would be required even to extend Professor McFadden's deeply flawed approach to other genres of apps. Because his approach does not offer but-for world prices for most apps, it cannot reliably determine which consumers are harmed.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on August 10, 2021.



Jeffrey T. Prince

August 10, 2021

Date

[152] Workpaper 31.

[153] McFadden Report, ¶ 218.

Appendix A

VITA

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EDUCATION

Ph.D.: Economics, Department of Economics, Northwestern University, 2004.
Dissertation Title: The Diffusion of Durable Information Technology Products.
M.A.: Economics, Department of Economics, Northwestern University, 2000.
B.A.: Economics, Miami University, 1998, *Summa Cum Laude*.
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FIELDS OF SPECIALIZATION

Primary: Industrial Organization
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ACADEMIC POSITIONS HELD

Professor of Business Economics and Public Policy (with tenure), Kelley School of Business, Indiana University, 2017-present.

Harold A. Poling Chair in Strategic Management, Kelley School of Business, Indiana University, 2015-present.

Chairperson, Department of Business Economics and Public Policy, Kelley School of Business, Indiana University, 2016-2019 & 2020-present.

Co-Director, Kelley Institute for Business Analytics, 2016-present.

Faculty Affiliate, Indiana University Data Science Program, 2018-present.

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University Fellow at the Technology Policy Institute, 2021-present.

Chief Economist, Federal Communications Commission, 2019-2020.

Associate Professor (with tenure) of Business Economics and Public Policy, Kelley School of Business, Indiana University, 2010-2017.

Visiting Scholar, Strategy Department, Kellogg Graduate School of Management, Northwestern University, Summer and Fall, 2015.

Visiting Scholar, Center of Business and Public Policy, McDonough School of Business, Georgetown University, Fall, 2015.

Cathie and Jerry Anderson Faculty Fellow, Kelley School of Business, Indiana University, 2013-2015.

Assistant Professor, Applied Economics and Management, Cornell University, 2004-2010 (promoted to Associate with tenure, July, 2010).

NONACADEMIC EXPERIENCE

National Security Agency, Cryptologic Mathematician in Director's Summer Program, Fort George G. Meade, Maryland, Summer 1998.

UNEXT, Consultant and Co-author for Online Masters Business Course in Vertical Integration, Chicago, Illinois, Summer 2001.

Nationwide Insurance, Actuarial Intern, Columbus, Ohio, Summer 1997.

EDITORIAL POSITIONS

Co-editor, *Journal of Economics and Management Strategy*, 2015-present.

Editorial Board member, *Information Economics and Policy*, 2008-present.

Co-editor, *Journal of Economics and Management Strategy Special Edition on Digital Transformation and the Business Revolution*, 2022 (expected).

BOOKS

Predictive Analytics for Business Strategy: Reasoning from Data to Actionable Knowledge, McGraw-Hill, 2019.

Managerial Economics and Business Strategy, *10th Edition*, with Michael R. Baye, McGraw-Hill, 2021 (expected).

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Managerial Economics and Business Strategy, *8th Edition*, with Michael R. Baye,

McGraw-Hill, 2014.

WORKING PAPERS

"How Much is Privacy Worth Around the World and Across Platforms?", with Scott Wallsten, 2020, in 2nd round at the *Journal of Economics and Management Strategy*. (Working version at SSRN)

"Optimal Promises: Application of a General Framework to Airline Schedule Times", with Daniel Simon, 2020, reject and resubmit at *Strategic Management Journal*. (Working version at SSRN)

"The Effect of International Travel on the Spread of Covid-19 in the U.S.", with Daniel Simon, 2020, under review. (Working version at SSRN)

"The Effect of Domestic Travel on the Spread of Covid-19 in the U.S.", with Daniel Simon, 2021, under review. (Working version on SSRN)

REFEREED PUBLICATIONS

"Mobile Internet Usage and Usage Based Pricing", with Shane Greenstein, 2020, forthcoming at the *Journal of Economics and Management Strategy*. (Working version at SSRN)

"Economics at the FCC: 2019-2020", with Allison Baker, Patrick Brogan, Octavian Carare, Nicholas Copeland, Patrick DeGraba, Steven Kauffman, Paul LaFontaine, Catherine Matraves, Sean Sullivan, Patrick Sun, and Emily Talaga, *Review of Industrial Organization*, 57, pp. 827-858, 2020.

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"Distinguishing Bandwidth and Latency in Households' Willingness-to-Pay for Broadband Internet Speed," with Yu-Hsin Liu and Scott Wallsten (lead article), *Information Economics and Policy*, 45, pp. 1-15, 2018. (Available at SSRN).

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"Information Technology and Patient Health: Analyzing Outcomes, Populations, and Mechanisms", with Seth Freedman and Haizhen Lin, *American*

Appendix A

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"Determinants of Private Long-Term Care Insurance Purchase in Response to the Partnership Program", with Haizhen Lin, *Health Services Research*, 51, 2, 687-703, 2016. (Working version at SSRN).

"Do Incumbents Improve Service Quality in Response to Entry: Evidence from Airlines' On-Time Performance", with Daniel Simon, *Management Science*, 61, 2, 372-390, 2015. (Working version at SSRN).

"Does Service Bundling Reduce Churn?", with Shane Greenstein, *Journal of Economics and Management Strategy*, 23, 4, 839-875, 2014. (Working version at SSRN).

"Indirect Network Effects and the Quality Dimension: A Look at the Gaming Industry", with Jin-Hyuk Kim and Calvin Qui, *International Journal of Industrial Organization*, 37, 6, 99-108, 2014. (Working version at SSRN).

"Is Dual Agency in Real Estate a Cause for Concern?", with Vrinda Kadiyali and Daniel Simon, *Journal of Real Estate Finance and Economics*, 48, 1, pp. 164-195, 2014. (Working version at SSRN).

"The Impact of the Partnership Long-term Care Insurance Program on Private Coverage", with Haizhen Lin, *Journal of Health Economics*, 32, 6, pp. 1205-1213, 2013. (Working version at SSRN).

"Racial Bias in Expert Quality Assessment: A Study of Newspaper Movie Reviews", with Lona Fowdur and Vrinda Kadiyali, *Journal of Economic Behavior and Organization*, 84, 1, pp. 292-307, 2012. (Working version at SSRN)

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"The Welfare Impact of Reducing Choice in Medicare Part D: A Comparison of Two Regulation Strategies", with Claudio Lucarelli and Kosali Simon, *International Economic Review*, 53, 4, pp. 1155-1177, 2012. (Working version at SSRN)

"Relating Inertia and Experience in Technology Markets: An Analysis of Households' Personal Computer Choices", *Applied Economics*, 43, 29, pp. 4501-4514, 2011. (Working version at SSRN)

"Are Risk Preferences Stable across Contexts? Evidence from Insurance Data", with Levon Barseghyan and Joshua Teitelbaum, *American Economic Review*, 101, 2, pp. 591-631, 2011. (Working version at SSRN)

"Is Time Inconsistency Primarily a Male Problem?", with Dan Shawhan, (lead article) *Applied Economics Letters*, 18, 6, pp. 501-504, 2011. (Working version at SSRN)

"Has the Internet Accelerated the Diffusion of New Products?", with Daniel Simon, *Research Policy*, 38, 8, pp. 1269-1277, 2009. (Working version at SSRN)

"How Do Households Choose Quality *and* Time to Replacement for a Rapidly Improving Durable Good?", *International Journal of Industrial Organization*, 27, 2, pp. 302-311, 2009. (Working version at SSRN)

"Multi-market Contact and On-Time Performance in the US Airline Industry", with Daniel Simon, *Academy of Management Journal*, 52, 2, pp. 336-354, 2009. (Working version at SSRN)

"Repeat Purchase amid Rapid Quality Improvement: Structural Estimation of the Demand for Personal Computers", (lead article) *Journal of Economics and Management Strategy*, 17, 1, pp. 1-33, 2008. (Working version at SSRN)

"Internet Adoption and Usage Patterns are Different: Implications for the Digital Divide", with Avi Goldfarb, (lead article) *Information Economics and Policy*, 20, 1, pp. 2-15, 2008. (Listed as the #1 most cited article for this journal since 2008: http://www.journals.elsevier.com/information-economics-and-policy/most-cited-articles/). (Working version at SSRN)

"The Beginning of Online/Retail Competition and Its Origins: An Application to Personal Computers", *International Journal of Industrial Organization*, 25, 1, pp. 139-156, 2007. (Working version at SSRN)

"The Diffusion of the Internet and the Geography of the Digital Divide in the United States", with Shane Greenstein, in (eds) Robin Mansell, Chrisanthi Avgerou, Danny Quah, and Roger Silverstone, The Oxford Handbook of Information and Communication Technologies, Oxford University Press, pp. 168-195, 2007. (NBER working paper No. W12182)

NON-REFEREED PUBLICATIONS

"Empirical Evidence of the Value of Privacy", with Scott Wallsten, forthcoming in the *Journal of European Competition Law and Practice*, 2021.

"The Economics of Digital Platforms: A Guide for Regulators", with Michael R. Baye, Global Antitrust Institute Report on the Digital Economy, 2020. (Available at SSRN)

"FCC Comments on Vertical Merger Guidelines", with Giulia McHenry, Patrick DeGraba, Eric Ralph, Catherine Matraves, Eugene Kiselev, and Aleksandr Yankelevich, February, 2020.

"Does Original Content Help Streaming Services Attract More Subscribers?", *Harvard Business Review*, April, 2018. (Available at HBR.org)

"Position Statement on Challenges Facing Online Video Distributors", FCC's Video Landscape Workshop, March, 2016.

"The Dynamic Effects of Triple Play Bundling in Telecommunications", Time Warner Research Program on Digital Communications, Winter, 2012. (Available here).

"The Geographical Diffusion of the Internet in the United States", with Shane Greenstein, in (eds) Munindar Singh, The Practical Handbook of Internet Computing, CRC Press, pp. 56-1 – 56-17, 2004.

TEACHING EXPERIENCE

Lecturer, 2022 (scheduled).
Digital Economics for Business.

Lecturer, 2019-2021.
Predictive Analytics for Business Strategy II. (MBA level)

Lecturer, 2018-2021.
Predictive Analytics for Business Strategy I. (MBA level)

Lecturer, 2011-2017.
Predictive Analytics for Business Strategy.

Lecturer, 2016.

Econometric Methods in Business II (PhD level).

Lecturer, Summer 2012-2014.
Introduction to Economics (Global Business Institute)

Lecturer, 2011.
Managerial Economics.

Lecturer, 2010.
Business Econometrics.

At Cornell:

Lecturer, 2006-2010.
Empirical Analysis of Industrial Organization (PhD level).

Lecturer, 2005-2010.
Introduction to Business Regulation.

Lecturer, 2007-2010.
Game Theory for Applied Economists (PhD level).

Lecturer, Summer 2007.
Gaming: In the Casino and Beyond (Cornell Adult University).

Guest Lecturer, 2005-2006.
Graduate Industrial Organization, Empirical methods (PhD level).

At Northwestern:

Teaching Assistant, 2000-2004.
Introductory Econometrics, Transportation, Intermediate Microeconomics, Honors Thesis Seminar, Advanced Econometrics.

Lecturer, 2002-2003.
Introductory Econometrics, Accelerated Probability and Statistics.

FELLOWSHIPS AND AWARDS

Best Research Poster, Research Conference on Communications, Information and Internet Policy, 2015.

Trustees Teaching Award, Indiana University, 2015.

Trustees Teaching Award Finalist, Indiana University, 2012, ’13, ’14, ‘15.

Certificate of Excellence in Reviewing, Information Economics and Policy, 2014.

Sauvain Teaching Award Nominee, 2014.

Innovative Teaching Award, Kelley School of Business, 2012.

Young Faculty Teaching Excellence Award, Cornell University, 2008.

Outstanding Graduate Student Teacher Award, Northwestern University, 2004.

Distinguished Teaching Assistant Award, Northwestern University, 2001,'02,'03,'04.

University Summer Fellowship, Northwestern University, 2003.

University Fellowship, Northwestern University, 1999-2000.

Teaching Assistant Fellow, Northwestern University.

George W. Thatcher Prize for top student in economics, Miami University, 1998.

Alumni Senior Prize for outstanding student in mathematics and statistics, Miami University, 1998.

Actuarial Exam P (equivalent based on passing pre-2000 Part 1 and Part 2 exams), 1998.

GRANTS AND OTHER FUNDING

Advanced Analytics for IU's Addictions Grand Challenge

NET Institute Summer Research Grant

Research Data Grant, Kelley School of Business

Time Warner Research Stipend

Cornell's Institute for the Social Sciences Theme Project Faculty Fellow

Cornell Institute for the Social Sciences Small Grant Award

INVITED PAPER PRESENTATIONS

"The Effect of International Travel on the Spread of Covid-19 in the U.S."

- Purdue, November, 2020.

"How Much is Privacy Worth Around the World and Across Platforms?"

- Kelley Faculty Research Series, IU Mexico Gateway, May, 2021.

- Game Theoretic and Behavioral Economic Insights on Social Media, February, 2021.
- Research Conference on Communications, Information and Internet Policy, February, 2021.
- NBER Economics of IT and Digitization Workshop, July, 2020.
- FTC PrivacyCon, July, 2020.

"Mobile Internet Usage and Usage Based Pricing"
- Research Conference on Communications, Information and Internet Policy, February, 2021.
- Federal Communications Commission, October, 2020.
- International Industrial Organization Conference, May, 2020.

"A Paradigm for Assessing the Scope and Performance of Predictive Analytics"
- Technology Policy Institute, February, 2018.

"Distinguishing Bandwidth and Latency in Households' Willingness-to-Pay for Broadband Internet Speed"
- Bureau of Economic Analysis, October, 2017.
- Technology Policy Institute, October, 2017.
- Research Conference on Communications, Information and Internet Policy, September, 2017.

"The Empirical Economics of Online Attention"
- Pomona College, March, 2019.
- Research Conference on Communications, Information and Internet Policy, September, 2017.
- Searle 8th Annual Conference on Internet Commerce, June, 2017.
- Federal Communications Commission, March, 2017.
- Media Economics Workshop, October, 2016.
- University of Oklahoma, September, 2016.
- International Industrial Organization Conference, April, 2016.
- American Economic Association Annual Meetings, January, 2016.
- Kellogg School of Management, November, 2015.
- Georgetown University, October, 2015.
- Research Conference on Communications, Information and Internet Policy, September, 2015.

"Does Competition Lead to Agglomeration or Dispersion in EMR Vendor Decisions?"
- International Industrial Organization Conference, April, 2017.

"The Effect of Competition on Toxic Pollution Releases"
- International Industrial Organization Conference, April, 2015.
- University of California, Davis, March, 2015.

Appendix A

"The Impact of Mergers on Quality Provision: Evidence from the Airline Industry"
- Strategic Management Society Conference "Strategies in a World of Networks," September, 2014.
- International Industrial Organization Conference, April, 2014.

"Measuring Consumer Preferences for Video Content Provision via Cord-Cutting Behavior"
- Cable Show Academic Workshop, April, 2014.
- Research Conference on Communications, Information and Internet Policy, September, 2013.

"Information Technology and Patient Health: Analyzing Outcomes, Populations, and Mechanisms"
- IUPUI, January, 2018
- Purdue University, November, 2014.
- ASHEcon Conference, June, 2014.
- University of Massachusetts, April, 2014.
- International Industrial Organization Conference, April, 2014.
- NBER Economics of IT and Digitization Workshop, July, 2013.

"Indirect Network Effects and the Quality Dimension: A Look at the Gaming Industry"
- Indiana University Economics Department, November, 2013.
- International Industrial Organization Conference, May, 2013.

"Does Service Bundling Reduce Churn?"
- NBER Economics of IT and Digitization Workshop, July, 2012.
- International Industrial Organization Conference, March, 2012.
- Federal Trade Commission, March, 2012.
- Michigan University, November, 2011.
- Research Conference on Communications, Information and Internet Policy, September, 2011.

"The Impact of the Partnership Long-term Care Insurance Program on Private Coverage"
- University of Cincinnati, October, 2012.

Appendix A

"Do Incumbents Improve Service Quality in Response to Entry: Evidence from Airlines' On-Time Performance"
- Ohio State University, November, 2012.
- Econometric Society North American Summer Meeting, June, 2011.
- Temple University, November, 2010.
- Miami University, October, 2010.
- International Industrial Organization Conference, May, 2010.

"Has the Internet Accelerated the Diffusion of New Products?"
- Bureau of Economic Analysis, November, 2009.

"Are Risk Preferences Stable across Contexts? Evidence from Insurance Data"
- Econometric Society North American Summer Meeting, June, 2008.

"Multi-market Contact and On-Time Performance in the US Airline Industry"
- International Industrial Organization Conference, May, 2008.

"The Welfare Impact of Reducing Choice in Medicare Part D: A Comparison of Two Regulation Strategies"
- ASHEcon Conference, June, 2010.
- International Industrial Organization Conference, April, 2009.
- Federal Trade Commission, March, 2008.

"Is Dual Agency in Real Estate a Cause for Concern?"
- International Industrial Organization Conference, May, 2008.
- Midwest Economic Association Annual Meeting, March, 2008.

"Internet Adoption Patterns and Usage are Different: Implications for the Digital Divide"
- University of Maryland, April, 2007.

"How Do Households Choose Quality and Time to Replacement for a Rapidly Improving Durable Good?"
- Kelley School of Business, February, 2010.
- Duke University, September, 2007.
- Cornell University, September, 2007.
- Econometric Society North American Summer Meeting, June, 2007.
- International Industrial Organization Conference, April, 2007.

"Relating Inertia and Experience in Technology Markets: An Analysis of Households' Personal Computer Choices"
- Dartmouth Winter IO Conference, January, 2006.

"The Beginning of Online/Retail Competition and Its Origins: An Application to

Personal Computers"
- International Industrial Organization Conference, April, 2006.
- Cornell University, March, 2006.
- ASSA SGE, January, 2006.

"Repeat Purchase amid Rapid Quality Improvement: Structural Estimation of the Demand for Personal Computers"
- Penn State University, April, 2007.
- Econometric Society World Conference, August, 2005.
- International Industrial Organization Conference, April, 2005.
- Miami University, March, 2005.
- ASSA SGE, January, 2005.
- Duke University, November, 2004.
- Cornell University, November, 2004.
- NBER Summer Institute, July, 2004.

EXPERT PANELS AND ENGAGEMENTS

Panel on Competition and Innovation, 14th Annual Innovation Economics Conference, August, 2021.

Privacy, Please? American Bar Association Panel on Valuing Privacy, April, 2021.

Two Think Minimum Podcast with Scott Wallsten and Sarah Oh, Technology Policy Institute, February, 2021. (Podcast link forthcoming)

Panel on the Economy of Spectrum Sharing and Business Development, NSF Virtual Workshop on New Paradigms in Intelligent Spectrum Management and Regulations, December, 2020.

Scientific Sense Podcast Interview with Gill Eapen, October, 2020. (Podcast link)

Panel on the Attention Economy, Technology Policy Institute Aspen Forum, October, 2020. (Online video)

Panel on Antitrust Policy and Intellectual Property (moderator), Northwestern/USPTO Conference on Innovation Economics, August, 2020.

Panel on STELAR/Retransmission Consent, Phoenix Center Telecom Symposium, December, 2019.

BU Technology Policy Research Initiative Conference on the Law and Economics of IP, July, 2019.

FTC Merger Retrospective Hearing, Federal Trade Commission, April, 2019 (Online video)

Panel on Consumer Protection and Regulation, Maurer School of Law, March, 2018.

Terminator or the Jetsons? The Economics and Policy Implications of Artificial Intelligence, Technology Policy Institute, February, 2018.

All Data is Health Data; The Impact of Data and Data Laws on Clinical Care, Innovation, and Research, Symposium at Hall Center for Law and Health, October, 2017.

Tools of Damages Estimation, IPO's Damages and Injunctions Committee Conference, June, 2017.

The Unlikely Pairing of Payers, Providers and Pharma for Patient Centered Analytics, Kelley Forum on Healthcare Analytics, September, 2016.

Challenges Faced by Online Video Distributors, Federal Communications Commission Video Landscape Workshop, March, 2016 (Online video)

The Future of Video Policy and Business Models, hosted by the Technology Policy Institute, January, 2014 (Online audio)

PUBLIC SPEECHES

"IoT and Telecom Policy"

- Nelms Distinguished E-Seminar Series, University of Florida, October, 2020.

"Delivering Econometrics Skills within a Business Analytics Curriculum"

- Robert Morris Teaching Economics Conference, February, 2018

"Critical Assessment of Correlation vs. Causality for Business Decisions"

- 180 Degrees Consulting, Indiana University, February, 2017

"Bringing Repeated Games to Life via Empirical Examples"

- McGraw-Hill Education Fall INXPO Event, October, 2016
- University of Phoenix School of Business Symposium, March, 2016
- McGraw-Hill Education Teaching Workshop for Professional Development, March, 2013

"Critical Assessment of Correlation vs. Causality for Public Policy"

- Vietnam Initiative with Indiana University, October, 2015

"As Graduates of Elder, You are Ready…"

- Cincinnati Elder High School Graduation Commencement, May, 2005

PUBLIC COMMENTARY

"People Lie When Answering Polls. Here's How to Fix It", with Scott Wallsten, *Technology Policy Institute Blog*, January, 2021. (Available at TPI)

"Travelers Coming from Italy May Have Driven First US Covid-19 Wave More Than Those From China, Study Suggests", with Daniel Simon, *The Conversation*, January, 2021. (Available at the Conversation)

"Improved Economic Analysis Should Be Lasting Part of Pai's FCC Legacy", with Babette Boliek and Jerry Ellig, *The Hill*, December, 2020. (Available at The Hill)

MEDIA COVERAGE

Specific Papers/Books/Public Commentary:

"Travelers Coming from Italy May Have Driven First US Covid-19 Wave More Than Those From China, Study Suggests"

- Reprint in Associated Press, Yahoo News

"How Much is Privacy Worth Around the World and Across Platforms?"

- "Facebook Would have to pay $3.50 Per Month to U.S. Users for Sharing Contact Info: Study" by Nandita Bose, *Reuters*, February 25, 2020. Reprint in *NY Times*. (Online version)

"A Paradigm for Assessing the Scope and Performance of Predictive Analytics"

- "A Paradigm for Assessing the Scope and Performance of Predictive Analytics – Economic and Policy Implications of AI," by Wallis G. Romzek, Technology Policy Institute, April 17, 2018. (Online version).

"Does Original Content Help Streaming Services Attract More Subscribers?"

- "Will Netflix Win the Streaming Wars?", Louis Foglia, BEME News, August, 2019. (Video).
- "Streaming Video: Original Content is the Hook," by David Marino-Nachison, Barron's Next, April 25, 2018. (Online version).

Predictive Analytics for Business Strategy

- "Kelley Professor's New Book 'Actively' Advocates the Role of Economics within Today's Analytics Boom," by George Vlahakis, Kelley School official blog, March 27, 2018. (Online version).

"The Impact of Mergers on Quality Provision: Evidence from the Airline Industry"

- "Flight Delay? Lost Luggage? Don't Blame Airline Mergers, Research Shows," by George Vlahakis, reprinted in *Science Daily*, May 23, 2017. (Online version).

"The Empirical Economics of Online Attention"

- "We Spend a Fixed Amount of Time Online Each Week (But People with Higher Incomes Spend Less)," by Julia Hann, Forbes, September 14, 2016. (Online version).

Appendix A

- "Let Them Eat Internet," by Tyler Cohen, *Marginal Revolution*, July 19, 2016. (Online version).
- "Consumers Have a Troubling Internet Habit That's Threatening Digital Media," by Myles Udland, *Business Insider*, July 19, 2016. (Online version).
- "Richer People Spend Less Time on the Internet," by Allee Manning, *Vocativ*, July 19, 2016. (Online version).

"The Impact of the Partnership Long-term Care Insurance Program on Private Coverage"

- "The Boomer Challenge: It's a Numbers Game," by Paul Barr, *Hospitals and Health Networks*, April 8, 2014. (Online version).

"Do Incumbents Improve Service Quality in Response to Entry: Evidence from Airlines' On-Time Performance"

- "Study Finds That Competition May Lead to More Airline Delays," by Hugo Martin, *LA Times*, December 22, 2013. (Online version).

"Racial Bias in Expert Quality Assessment: A Study of Newspaper Movie Reviews"

- "Psychology Uncovers Racism at the Movies," by Dr. Raj Persaud and Adrian Furnham, *Psychology Today*, September 5, 2015. (Online version)
- "Men in Black the movie – but men in white would be a better film?," by Dr. Raj Persaud and Adrian Furnham, *Huffington Post*, May 22, 2012. (Online version).

"The Welfare Impact of Reducing Choice in Medicare Part D: A Comparison of Two Regulation Strategies"

- "Medicare As We've Known It Isn't an Option," by Betsy McCaughey, *Wall Street Journal*, April 27, 2011. (Online content).

"Internet Adoption Patterns and Usage are Different: Implications for the Digital Divide"

- "People below 'digital divide' would use the Internet more, if they had it," by Bill Steele, *Cornell Chronicle*, April 18, 2008. (Online version).
- Invited guest for "Digital Divide," *Nevada Public Radio*. (Online content).

Expert Opinion:

"ISP/Website 'Mutuality of Interests' – or Retrans Blackouts – Among Net Neutrality Reversal Possibilities," *Communications Daily*, Vol. 34, No. 17, January, 2014.

PROFESSIONAL SERVICE

Research Conference on Communications, Information and Internet Policy (TPRC) Program Committee, 2017-present.

International Industrial Organization Conference (IIOC) Local Organizer, 2018.

Midwest Health Economics Conference Local Organizing Committee, 2016.

European Conference on Information Systems (ECIS) Associate Editor of the track "Decision Analytics, Big Data, and Visualization," 2016.

International Conference on Information Systems (ICIS) Associate Editor of the track "Decision Analytics, Big Data, and Visualization," 2014.

International Industrial Organization Conference (IIOC) Program Committee, 2012-2014.

Ad hoc referee for:
Agricultural and Resource Economics Review, American Economic Journal: Applied Economics, American Economic Review, Applied Economics, Applied Financial Economics, B.E. Journal of Economic Analysis & Policy, Communications of the Association for Information Systems, Economic Inquiry, Economics of Education Review, Economics of Innovation and New Technology, Economics Letters, Geneva Papers on Risk and Insurance, Growth and Change: A Journal of Urban and Regional Policy, Health Economics, Health Services Research, Information Economics and Policy, International Economic Review, International Journal of Industrial Organization, Israel Science Foundation, Journal of Competition Law and Economics, Journal of Economics and Management Strategy, Journal of the European Economic Association, Journal of Gerontology, Journal of Health Economics, Journal of Industrial Economics, Journal of Policy Analysis and Management, Journal of Public Economics, Journal of Risk and Insurance, Journal of Rural Studies, Journal of Urban Technology, Leverhulme Trust, Management Science, Marketing Science, National Science Foundation, Organizational Science, Oxford Bulletin of Economics and Statistics, Quantitative Marketing and Economics, Quarterly Journal of Economics, Quarterly Review of Economics and Finance, RAND Corporation, RAND Journal of Economics, Research Policy, Review of Economics and Statistics, Review of Industrial Organization, Review of Network Economics, Social Behavior and Personality, Southern Economic Journal, Strategic Management Journal, Telecommunications Policy, Transportation Research Part E, U.S.-Israel Binational Science Foundation, World Development
External tenure/promotion reviewer for:

Drexel University, Emory University, Fairfield University, Georgetown University, Loyola University Maryland, Purdue University, University of Colorado, University of Georgia, University of Massachusetts, University of Oklahoma

External program reviewer for:
Ball State University Economics

DISCUSSANT ACTIVITIES

NBER Economics of Digitization Summer Institute Meeting, July, 2021
- "Browsers Don't Lie? Gender Differences in the Effects of Covid-19 Lockdowns on Digital Activity and Time Use," by Amalia R. Miller, Kamalini Ramdas, and Alp Sungu
- "Does Telemedicine Transcend Disparities or Create a Digital Divide? Evidence from the Covid-19 Pandemic," by Jeffrey McCullough, Kartik K. Ganju, and Chandy Ellimoottil

NBER Economics of Digitization Summer Institute Meeting, July, 2018
- "Steering Incentives and Bundling Practices in the Telecommunications Industry," by Brian McManus, Aviv Nevo, Zachary Nolan, and Jonathan W. Williams

International Industrial Organization Conference, April, 2017
- "Price-Linked Subsidies and Health Insurance Markups," by Sonia Jaffe and Mark Shepard

NBER Economics of Digitization Meeting, March, 2017
- "Using Massive Online Choice Experiments to Measure Changes in Well-being," by Erik Brynjolfsson, Felix Eggers, and Avinash Gannamaneni

International Industrial Organization Conference, April, 2016
- "Using Matching to Study Merger: An Application to the U.S. Airline Industry," by Zexuan Liu, Pallab Ghosh, and Qihong Liu
- "Market Structure with the Entry of Peer-to-Peer Platforms: The Case of Hotels and Airbnb," by Chiara Farronato and Andrey Fradkin

Searle Center Conference on Innovation Economics, June, 2015
- "How Do Open Standards Influence Inventive Activity? Evidence from the IETF," by Wen Wen, Chris Forman, and Sirkka Jarvenpaa

Appendix A

Searle Center Conference on Internet Search and Innovation, June, 2015
- "Match Quality, Search, and the Internet Market for Used Books," by Sara Fisher Ellison
- "E-Book Pricing and Vertical Restraints," by Babur De los Santos and Matthijs Wildenbeest

International Industrial Organization Conference, April, 2015
- "Do Private Medicare Firms Face Lower Costs?," by Keaton Miller
- "The Market for Electric Vehicles: Indirect Network Effects and Policy Impacts," by Yiyi Zhou

Searle Center Research Roundtable on Patents and Technology Standards: The Data Sets, April, 2015

American Economic Association Annual Meetings, Pricing and Resource Allocation in Telecommunications, January, 2015
- "Employing Auctions to Allocate Scarce Resources," by John Mayo and David Sappington

American Economic Association Annual Meetings, Digital Media Economics, January, 2015
- "Super Returns? The Effects of Ads on Product Demand," by Seth Stephens-Davidowitz, Hal Varian, and Michael D. Smith

Searle Center Conference on Internet Search and Innovation, June, 2014
- "Auction vs. Posted-Price: Market Mechanism, Lender Behaviors, and Transaction Outcomes in Online Crowdfunding," by Zaiyan Wei and Mingfeng Lin

Research Roundtable on the Law and Economics of Digital Markets, July, 2013
- "Digital Music Consumption on the Internet," by Bertin Martens and Luis Aguiar

Searle Center Conference on Internet Search and Innovation, June, 2013
- "When Does Retargeting Work? Information Specificity in Online Advertising," by Anja Lambrecht and Catherine Tucker
- "Local News Online: Aggregators, Geo-Targeting and the Market for Local News," by Lisa George

International Industrial Organization Conference, May, 2013
- "The Impact of Privacy Policy on the Auction Market for Online Display Advertising," by Garrett Johnson
- "Transactions in Two-Sided Markets," by Alexei Alexandrov and Daniel Spulber

American Economic Association Annual Meetings, Economics of the Internet, January,

Appendix A

2013
- "Supply-Side Responses to Privacy Protection," by Avi Goldfarb and Catherine Tucker

Searle Center Book Preview Roundtable, December, 2012
- *Innovation from the Edges: The Economics of Creating the Commercial Internet,* by Shane Greenstein

Searle Center Conference on Internet Search and Innovation, June, 2012
- "News Aggregators and Competition among Newspapers," by Doh-Shin Jeon and Nikrooz Nasr Esfahani
- "Technology Shocks in Multi-Sided Markets: The Impact of Craigslist on Local Newspapers," by Robert Seamans and Feng Zhu

Midwest Health Economics Conference, May, 2012
- "The Anticipatory Effects of Medicare Part D on Drug Utilization," by Abby Alpert

International Industrial Organization Conference, March, 2012
- "Intra-Household Effects on Demand for Telephone Service: Empirical Evidence," by Ching-I Huang
- "Unobserved Risk Type and Sorting: Signaling Game in Online Credit Markets," by Kei Kawai, Ken Onishi, and Kosuke Uetake

NBER Economics of Digitization Meeting, February, 2012
- "The Effect of Localization in News Aggregators on Local News Consumption," by Susan Athey and Markus Mobius

Federal Trade Commission Microeconomics Conference, November, 2011
- "Do Firms Game Quality Ratings? Evidence from Mandatory Disclosure of Airline On-Time Performance," by Silke Forbes, Mara Lederman, and Trevor Tombe

International Industrial Organization Conference, May, 2010
- "Competition in Public School Districts: Student Sorting, School Quality Determination, and School Entry," by Nirav Mehta
- "A Model of Entry and Network Access Competition in Local Telephony," by Gustavo Marcos and Eduardo Saavedra

International Industrial Organization Conference, April, 2009
- "Consumer Search and Online Demand for Durable Goods," by Jun Kim, Bart Bronnenberg, and Paulo Albuquerque
- "Price Controls and Competition in Gasoline Retail Markets," by Juan Esteban Carranza and J.F. Houde

International Industrial Organization Conference, May, 2008
- "A Simple Model of Pricing for Non-storable Goods in Oligopoly: Some Considerations on Airline Pricing Behaviour," by Marco Alderighi

International Industrial Organization Conference, April, 2007
- "Markov Perfect Industry Dynamics with Many Firms," by Gabriel Weintraub

International Industrial Organization Conference, April, 2006
- "Price, Price Dispersion and Number of Sellers at a Low Entry Cost Shopbot," by Michelle Haynes and Steve Thompson

International Industrial Organization Conference, April, 2005
- "Asymmetric Advertising Costs as a Barrier to Entry: Evidence from Theatrical Motion Pictures," by Charles Moul

BOOK REVIEWS

Bekes, G. and Kezdi, G., *Patterns, Causality and Prediction: Data Analysis for Business, Economics and Policy*, Cambridge University Press, 2017.

Lesser, W., *American Business Regulation: Understand, Survive, and Thrive*, M.E. Sharpe, 2015.

EXPERT REPORTS, DEPOSITIONS, AND TESTIMONY

Testimony (5)

Qualcomm Incorporated v. Apple Incorporated (Case No. 3:17-cv-1375), United States District Court for the Southern District of California, March 7 & 8, 2019

Apple Inc. v. Wi-LAN Inc. (Case No. 14cv2235-DMS w/ 14cv1507-DMS), United States District Court for the Southern District of California, July 25 & 26, 2018

ContentGuard, Inc. v. Apple, Inc. (Case No. 2:13-CV-1112), United States District Court for the Eastern District of Texas Marshall Division, November 13 & 16, 2015

ContentGuard, Inc. v. Google, Inc. (Case No. 2:14-CV-61), United States District Court for the Eastern District of Texas Marshall Division, September 16, 2015

Wi-LAN Inc. v. Apple, Inc. (Case No. 2:12-CV-0600-JRG), United States District

Appendix A

Court for the Eastern District of Texas Marshall Division, October 17, 2013

Deposition (7)

Wi-LAN Inc. v. Apple Inc. (Case No. 3:14-cv-02235-DMA-BLM), United States District Court for the Southern District of California, June 11, 2019
Qualcomm Inc. v. Apple Inc. (Case No. 3:17-cv-1375), United States District Court for the Southern District of California, November 7, 2018

Apple Inc. v. Qualcomm Inc. (Case No. 17cv0108 GPC NLS), United States District Court for the Southern District of California, October 19, 2018

Apple Inc. v. Wi-LAN Inc. (Case No. 14cv2235-DMS w/ 14cv1507-DMS), United States District Court for the Southern District of California, April 5, 2018

Wi-LAN Inc. v. Kyocera Communications (Case No. 2:13-CV-202-JRG), United States District Court for the Eastern District of Texas Marshall Division, September 4, 2015

ContentGuard Holdings Inc. v. Amazon, Inc., et al. (Case No. 2:13-CV-1112-JRG) and ContentGuard, Inc. v. Google, Inc. (Case No. 2:14-CV-61), United States District Court for the Eastern District of Texas Marshall Division, June 1-3, 2015

Wi-LAN Inc. v. HTC Corporation, HTC America, and Exedea, Inc. (Case No. 2:11-CV-00068) and Wi-LAN Inc. v. Apple, Inc., et al. (Case No. 2:12-CV-0600-JRG), United States District Court for the Eastern District of Texas Marshall Division, August 22, 2013

Expert Report (8)

Dennis McGrath et al. v. Marriott International, Inc. et al. (Case No. 8:19-md-2879-PWG), United States District Court for the Southern District of Maryland, July 12, 2021.

Wi-LAN Inc. v. Apple Inc. (Case No. 3:14-cv-02235-DMA-BLM), United States District Court for the Southern District of California, April 19, 2019

Qualcomm Inc. v. Apple Inc. (Case No. 3:17-cv-1375), United States District Court for the Southern District of California, September 18, 2018

Apple Inc. v. Qualcomm Inc. (Case No. 17cv0108 GPC NLS), United States District Court for the Southern District of California, June 29, 2018

Apple Inc. v. Wi-LAN Inc. (Case No. 14cv2235-DMS w/ 14cv1507-DMS),

United States District Court for the Southern District of California, February 15, 2018

Wi-LAN Inc. v. Kyocera Communications (Case No. 2:13-CV-202-JRG), United States District Court for the Eastern District of Texas Marshall Division, August 10, 2015

ContentGuard Holdings Inc. v. Amazon, Inc., et al. (Case No. 2:13-CV-1112-JRG) and ContentGuard, Inc. v. Google, Inc. (Case No. 2:14-CV-61), United States District Court for the Eastern District of Texas Marshall Division, May 8, 2015

Wi-LAN Inc. v. HTC Corporation, HTC America, and Exedea, Inc. (Case No. 2:11-CV-00068) and Wi-LAN Inc. v. Apple, Inc., et al. (Case No. 2:12-CV-0600-JRG), United States District Court for the Eastern District of Texas Marshall Division, July 19, 2013

CONSULTING

Provided consulting expertise to various clients on topics including: telecommunications policy, competition policy and antitrust, damage calculations, privacy valuation, and survey design and analysis.

MEMBERSHIPS

American Economic Association.

Industrial Organization Society.

Academy of Management.

Association for Information Systems.

Team member for Cornell's Institute for the Social Sciences Theme Project, Getting Connected: Social Science in the Age of Networks, 2005-2008.

UNIVERSITY SERVICE

Member of Diversity, Equity & Inclusion Task Force, 2020-2021.

Member of Hiring Committee for Business Economics and Public Policy, 2017-2018, 2015-2016 & 2010-2011.

Chair of Hiring Committee for Business Economics and Public Policy, 2014-2015 & 2013-2014.

Kelley Direct Policy Committee, 2014-2016.

Judge for Kelley Honors Case Competition, 2016.

Judge for Deloitte Undergraduate Case Competition, 2017, 2015, 2011.

Co-founder and Judge for Economic Consulting Case Competition (EC3), sponsored by the Keystone Group, 2011-2015.

Co-founder and Co-organizer for BEPP "Eat, Meet, & Compete," 2012-2015.

Undergraduate Policy Committee, 2012-2014 & 2010-2011.

Doctoral Advisor for Business Economics and Public Policy, 2011-2012.

Doctoral Policy Committee, 2011-2012.

Judge for Net Impact Sustainable Business Club 2010 Case Competition, 2010.

At Cornell:
Applied Economics and Management Petitions Committee, 2007-2010.

Policy Analysis and Management External Hiring Committee, 2006-2007 & 2009-2010.

Mann Café Advisory Board, 2007-2010.

Institute for the Social Sciences Small Grant Program Committee, 2008.

Biz Quiz Faculty Advisor, 2008.

Applied Economics and Management Seminar Committee, 2005-2007.

Judge for Globalize '07, Cornell Hotel School, 2007.

Mann Library Vendor Evaluation Sub-committee, 2006.

PHD STUDENTS

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Thanasin Tanompongphandh
Jiahong Zhang
Lona Fowdur
Anirban Mukherjee
Marc Bellemare (Substitute member)
Hyunkyung Choe
Daniel Shawhan

External Proposal Reviewer:
Andres Jola Sanchez (chair)
Mohammad Ghuloum
Kyle Bradley

MASTERS STUDENTS
Committee Member:
Malcolm Wade (Johns Hopkins, Systems Engineering)

Appendix B

Prior Testimony

JEFFREY T. PRINCE

Testimony

Qualcomm Incorporated v. Apple Incorporated (Case No. 3:17-cv-1375), United States District Court for the Southern District of California, March 7 & 8, 2019

Apple Inc. v. Wi-LAN Inc. (Case No. 14cv2235-DMS w/ 14cv1507-DMS), United States District Court for the Southern District of California, July 25 & 26, 2018

Deposition

Wi-LAN Inc. v. Apple Inc. (Case No. 3:14-cv-02235-DMA-BLM), United States District Court for the Southern District of California, June 11, 2019

Qualcomm Inc. v. Apple Inc. (Case No. 3:17-cv-1375), United States District Court for the Southern District of California, November 7, 2018

Apple Inc. v. Qualcomm Inc. (Case No. 17cv0108 GPC NLS), United States District Court for the Southern District of California, October 19, 2018

Apple Inc. v. Wi-LAN Inc. (Case No. 14cv2235-DMS w/ 14cv1507-DMS), United States District Court for the Southern District of California, April 5, 2018

Documents Relied Upon

Academic Articles

- Anja Lambrecht et al., "How Do Firms Make Money Selling Digital Goods Online?" *Mark Lett*, 25(3), 2014, pp. 331–341.
- Avi Goldfarb and Catherine Tucker, "Digital Economics," *Journal of Economic Literature*, 57(1), 2019, pp. 3–43.
- Aviv Nevo, "Measuring Market Power in the Ready-to-Eat Cereal Industry," *Econometrica*, 69(2), 2001, pp. 307–342.
- Juan L. Nicolau and Ricardo Sellers, "The Free Breakfast Effect: An Experimental Approach to the Zero Price Model in Tourism," *Journal of Travel Research*, 51(3), 2012, pp. 243–249.
- Kristina Shampanier et al., "Zero as a Special Price: The True Value of Free Products," *Marketing Science*, 26(6), 2007, pp. 742–757.
- Raoul Kubler et al., "App Popularity: Where in the World Are Consumers Most Sensitive to Price and User Ratings?" *Journal of Marketing*, 82, 2018, pp. 20–44.

Books and Book Chapters

- B. Douglas Bernheim and Michael D. Whinston, "*Microeconomics*," (New York, NY: McGraw-Hill/Irwin, 2008).
- Jack Johnston and John DiNardo, "*Econometric Methods*," Fourth Edition, (New York, NY: McGraw-Hill, 1997).
- James H. Stock and Mark W. Watson, "*Introduction to Econometrics*," (Upper Saddle River, NJ: Pearson, 2015).

Depositions

- Deposition of Daniel L. McFadden, August 3, 2021.
- Deposition of Einer Elhauge, July 30, 2021.

Expert Reports

- Expert Report of Daniel L. McFadden, June 1, 2021.
- Expert Report of Einer Elhauge, June 1, 2021.
- Expert Report of Lorin Hitt, August 10, 2021.

Appendix C

- Expert Report of Robert Schmalensee, August 10, 2021.
- Expert Report of Robert D. Willig, August 10, 2021.

Legal Documents

- Second Amended Consolidated Class Action Complaint, *In re Apple iPhone Antitrust Litigation*, September 5, 2013.
- Trial Testimony of Dr. David Evans, *Epic Games, Inc. vs. Apple, Inc.*, May 11, 2021.
- Trial Testimony of Mr. Timothy Sweeney, *Epic Games, Inc. vs. Apple, Inc.*, May 3, 2021.

Websites

- "A Better App Store Pricing Matrix," *Equinux*, January 24, 2019, available at https://www.equinux.com/us/appdevelopers/pricematrix.html, accessed on July 26, 2021.
- "App Store Review Guidelines," *Apple*, available at https://developer.apple.com/app-store/review/guidelines/, accessed on July 31, 2021.
- Chris Welch, "Netflix Stops Offering In-App Subscriptions for New and Returning Customers on iOS," *The Verge*, December 28, 2018, available at https://www.theverge.com/2018/12/28/18159373/netflix-in-app-subscriptions-iphone-ipad-ios-apple, accessed on July 31, 2021.

Bates Stamped Documents

- PLAYTIKA_000004

D. MORE DETAILS ON PROFESSOR MCFADDEN'S APPROACH

1. At a high level, Professor McFadden's methodology to infer consumers' price sensitivity and developers' costs for each app's downloads and in-app purchase items—and ultimately determine "harm" and calculate "damage"—proceeds in 4 stages:

a. He offers two simplified equations to reflect all app developers' and consumers' behavior (i.e., his **"model"**).[1]

i. For consumers, he proposes an aggregate demand curve—in which he asserts that there is a particular form of relationship between each app's price and the aggregate quantity of purchases made by all consumers for that app over a particular time period (such as a month or year).[2] He proposes a similar aggregate demand curve for each app's in-app purchase items, although he aggregates all of the items available for any given app.[3]

ii. For developers, he proposes that each developer ignores the decisions of other apps in setting prices for each app it offers, and chooses its prices for downloads and in-app purchases to maximize its profits net of Apple's commission, while ignoring any changes in market conditions *other* than Apple's commission.[4]

b. He **estimates** the value of this model's key relationship—consumer price sensitivity, i.e., the amount by which quantity demanded falls when prices rise—using actual prices, quantities, and commissions from a small (e.g., 0.1 percent) sample of the Apple transaction data, together with a few benchmark profit margins that he calculates from six firms' accounting records.[5]

[1] McFadden Report, Appendix E, ¶¶ 29–30.
[2] McFadden Report, Appendix E, ¶ 29.
[3] McFadden Report, Appendix E, ¶ 30.
[4] McFadden Report, ¶¶ 171–172.
[5] McFadden Report, ¶¶ 189–195, Appendix E, ¶¶ 24, 34.

From this estimated price sensitivity he calculates two **demand elasticities** for each app—one for its downloads, and one for its in-app purchases.[6] Then, his assumptions about developer behavior allow him to estimate each developer's **marginal cost** for each app (or each app's aggregated in-app purchase items) and **profit margin**.[7]

c. He then uses his estimated values for the demand elasticity and the marginal cost, along with observed commissions and prices, to **predict** which developers would change their app (and in-app purchase) prices—and by how much—if Apple were to reduce its commission to a flat 12 percent on all transactions (i.e., which apps would have lower but-for prices).[8] He interprets lower but-for prices as a sign that Apple's allegedly anticompetitive conduct harmed consumers.[9] Flat or higher but-for prices, however, he interprets as a sign of lack of harm.[10]

d. He applies these predicted price changes to the purchases consumers actually made to **determine which consumers are harmed.**[11] He claims that a consumer is harmed if the consumer made a single app or in-app purchase with a lower but-for price.[12] He also calculates the total amount of harm across consumers.[13]

D.1. Modeling

2. In order to predict but-for prices, Professor McFadden models the behavior of both developers and consumers.[14]

[6] McFadden Report, Appendix E, ¶¶ 29–30.
[7] McFadden Report, Appendix E, ¶ 36.
[8] McFadden Report, Appendix E, ¶ 39. He considers other but-for commission rates as sensitivities.
[9] McFadden Report, Appendix E, ¶ 46.
[10] McFadden Report, ¶¶ 225–226.
[11] McFadden Report, ¶ 224.
[12] McFadden Report, ¶ 226.
[13] McFadden Report, Appendix E, ¶¶ 46–48.
[14] McFadden Report, Section VI.D.1 and Section VI.D.2, respectively.

D.1.1. Developers

3. Professor McFadden starts by characterizing developers' price-setting behavior by assuming that developers maximize their profits, taking as given consumers' preferences, the costs they face in delivering their services to consumers, and Apple's commission.[15] This generates a particular set of equations that relate costs, prices, commissions, and consumers' price sensitivity.[16] These equations are central to the rest of Professor McFadden's methods—both in the estimation phase and in the prediction phase.

D.1.2. Consumers

4. To describe the behavior of app consumers, Professor McFadden introduces two demand equations: one for app downloads and one for in-app purchases.[17] These equations, or "demand curves," relate an app's (or in-app purchase item's) price with the total quantity of downloads (or in-app purchases) consumers will make.

5. Professor McFadden assumes that the quantity demanded of any given product (app download or in-app purchase item) only depends on the product's own price; it does not depend on the prices of related apps (substitutes or complements).[18] He also partially models the interrelation between demand for downloads and for in-app purchases for the same app.[19] While the demand for in-app purchases for a given app depends on the number of downloads of that app (and therefore on the price of the downloads), the number of downloads for a given app does *not* depend on the prices of in-app purchases for that app.[20] Professor McFadden recognizes that consumers may exhibit different price sensitivities for different app genres or "categories."[21] However, he assumes that consumers exhibit the same price sensitivity across all apps within a given genre.[22]

[15] McFadden Report, ¶¶ 167, 171–172.
[16] McFadden Report ¶ 171, Equations (2) and (3).
[17] McFadden Report, ¶ 180, Equations (8) and (9).
[18] McFadden Report, ¶ 180, Equations (8) and (9).
[19] McFadden Report, ¶ 180, Equation (9).
[20] McFadden Report, ¶ 180, Equations (8) and (9).
[21] McFadden Report, ¶ 210.
[22] McFadden Report, ¶ 210.

Appendix D

D.2. Estimation

6. The modeling steps above yield relationships between the key economic variables at hand—commissions, costs, consumers' price sensitivity, prices, and quantities. The next step is to use observed data to infer many of these variables—a process called **estimation**. Professor McFadden observes commissions, prices, and quantities, but must infer costs and consumers' price sensitivity.[23] His approach is first to infer consumers' price sensitivity—the "slope of the demand curve" which, together with an app's price, identifies the elasticity of demand—and then subsequently infer costs using the relationships listed above.[24]

D.2.1. Consumers' price sensitivity

7. Professor McFadden estimates consumers' price sensitivities using a technique called the generalized method of moments ("GMM").[25] At a high level, this technique seeks the values of a model's parameters that best explain or "fit" the data we observe. Intuitively, it is closely related to familiar techniques like linear regression (and in fact, linear regression is just a special case of GMM).[26] In the present context, Professor McFadden is searching for the consumer price sensitivities that best explains the relationship between prices and quantities demanded—taking into account the fact that prices and quantities are jointly determined with causality running in both directions, which invalidates a straightforward linear regression.[27]

8. However, rather than letting the actual data tell him what it finds consumers' price sensitivities to be, Professor McFadden has imposed, ex ante, constraints on what price sensitivities his model will even *consider* when attempting to find the one that best explains the data.[28] Here, I explain how this works. First, Professor McFadden observes profit margins for a few selected firms in each

[23] McFadden Report, Appendix E, ¶¶ 29–31, 34, 36.

[24] McFadden Report, Appendix E, ¶ 36.

[25] McFadden Report, Appendix E, ¶ 31.

[26] Jack Johnston and John DiNardo, "Econometric Methods," Fourth Edition, (New York, NY: McGraw-Hill, 1997), at pp. 329–330.

[27] Technically, Professor McFadden is using a technique called instrumental variables regression. Instead of looking for the observed relationship between the dependent (quantity demanded) and independent (price) variables, instrumental variables looks for a relationship between the dependent variable and instrumental variables—variables that are closely related to the independent variables, but which the econometrician argues are subject to the reverse causation concern. Whether Professor McFadden's chosen instrumental variables satisfy this condition is open for debate, but I do not address it in my report.

[28] McFadden Report, Appendix E, ¶ 32.

genre (subject to issues I consider in §7.2).[29] Then, Professor McFadden requires that any price sensitivities up for consideration must imply[30] profit margins for all the apps in his data that, on average, are generally consistent with the few profit margins he observes.[31] Mathematically, this is equivalent to restricting that consumers' price sensitivities lie in a particular interval.[32]

9. The process described above is applied to a filtered, modified sample of the Apple transaction data; I describe the filtering process in §8.1.

10. Professor McFadden aggregates across transactions for the same consumer, and across consumers for the same item.[33] The result is a single observation per app or in-app purchase item per month, which contains average purchase price, total purchase quantities, and a single average commission, which is calculated across all observations for the same app in the same year. He applies the estimation technique to these aggregated observations, separately for Games and for the combination of Music and Entertainment.[34] With the estimated demand curves in hand, he then infers marginal costs according to the procedure described next.[35]

D.2.2. Marginal costs and profit margins

11. After estimating consumers' price sensitivities, Professor McFadden infers marginal costs for each app and in-app purchase item.[36] The process works as follows. Professor McFadden assumes that developers are maximizing profits—taking costs, commissions, and consumers' price sensitivities as given—in both the actual world and in the but-for world.[37] Under the set of strict assumptions that Professor McFadden places on developer behavior, there exists a specific, tight relationship between marginal costs, prices, commissions, and consumers' price sensitivities.[38] After estimating consumers' price sensitivities, Professor McFadden will know everything about the actual world except marginal costs—

[29] McFadden Report, ¶¶ 189–195.
[30] See §D.2.2 of this Appendix.
[31] McFadden Report, Appendix E, ¶ 32.
[32] See §F.3 of this Appendix for proof.
[33] McFadden Report, Appendix E, ¶ 23.
[34] McFadden Report, Appendix E, ¶ 34.
[35] McFadden Report, Appendix E, ¶ 36.
[36] McFadden Report, Appendix E, ¶ 36.
[37] McFadden Report, ¶¶ 167–169.
[38] McFadden Report, Appendix E, ¶ 36.

price, consumers' price sensitivities, and Apple commissions. For each app, assuming the developer sets its prices ignoring the decisions of other developers (which I discuss in §6.3.1), there will be only one marginal cost for which the price he observes in the data would maximize the developer's profit—and this is the marginal cost he infers.[39]

12. To apply the constraint Professor McFadden imposed on the average profit margin, one requires the profit margin of each app.[40] This can be directly calculated as the observed price minus this inferred marginal cost, all divided by the observed price.

13. This close relationship between consumers' price sensitivities, marginal costs, and profit margins is an important concept, because if any of these variables is calculated incorrectly or unreliably, so are all the others. Additionally, consumer harm relies directly upon accurate estimation of consumers' price sensitivities and marginal costs. If either of these variables is calculated incorrectly, then Professor McFadden's estimation of consumer harm is wrong.

D.3. Prediction

14. Professor McFadden next uses his estimated price sensitivities and marginal costs to simulate the hypothetical prices that developers would charge if Apple were to offer what he proposes is the "but-for commission rate"—12 percent, uniformly applied to all transactions.[41] He does not model Apple's (or other platform operators') conduct, but instead assumes this commission rate from an informal review of other platforms.[42] Then, he obtains the prices in the but-for world using the same relationship that gave him his marginal cost estimates above, but this time, he knows the marginal costs and infers the prices, rather than the other way around.[43]

[39] McFadden Report, ¶¶ 167, Appendix E, ¶ 36.
[40] McFadden Report, Appendix E, ¶¶ 32–34.
[41] McFadden Report, Appendix E, ¶¶ 41–45.
[42] McFadden Report, ¶¶ 136.
[43] McFadden Report, Appendix E, ¶¶ 36, 41–43.

D.4. Determining harm to any individual class member

15. Professor McFadden calculates the alleged overcharge due to Apple's alleged anticompetitive conduct as the difference between the actual and but-for prices charged by developers.[44] In his report, Professor McFadden classified a given consumer as "harmed" if the consumer engaged in at least one transaction for which he estimated a lower price in the but-for world.[45] But as I explain in §4, Professor McFadden has changed his opinion on this,[46] and he and I now agree that one should assess harm using the total cost of all the purchases an account made—i.e., whether the account is harmed "on net."

16. One final subtlety is that Professor McFadden does not explicitly list his predicted but-for price for any given in-app purchase item. The fact that his demand functions are log-linear implies that he is assuming that all in-app purchase items for the same app in the same year change their price by the same dollar amount.[47] Professor McFadden argued during his deposition that he assumes that they all change their prices by the same percentage amount.[48] My primary conclusions in this report do not change—and in fact are often stronger—if I assume that they all change their prices by the same percentage amount.

17. In order to calculate class wide overall "damage" he multiplies the estimated overcharge by actual quantities.[49] Because, as mentioned above, he does not provide estimates for the full collection of apps but instead only for a filtered sample, he extrapolates the "damage" he finds within each category or genre by assuming that damages are proportional to Apple's commissions;[50] e.g., if his filtered sample accounts for only 30 percent of Apple's commissions in the

[44] McFadden Report, Appendix E, ¶ 46.

[45] McFadden Report, ¶ 226.

[46] McFadden Deposition, 201:22–202:3 ("Q: So you agree that if a consumer spent money on an app whose but-for price is lower than another app whose but-for price is higher, the net harm of Apple's conduct would need to account for both those price changes; is that right? A: Yes, that's the way I do it, and I think that's economically appropriate.").

[47] McFadden Report, Equation (9).

[48] McFadden Deposition, 169:11–23 ("Q: so sticking with my hypothetical of an app that offers in-app purchases in the real world at 2.99, 3.99, and 4.99, in your but-for-world calculations are you – does your model change the price of those three offerings by the same dollar amount? A: No, it changes them by the same percentage amount; so that if the…consumer prices for – for apps in that genre go down by 8 percent, then that 8 percent reduction is applied to each individual transaction. So 8 percent of 1.99, 8 percent of 2.99, 8 percent of 3.99.").

[49] McFadden Report, Appendix E, ¶ 46.

[50] McFadden Report, Appendix E, ¶¶ 47–48.

genre, then he assumes that his calculated "damages" are also only 30 percent of true "damages."

E. CONCLUSIONS REGARDING WHICH CONSUMERS ARE HARMED ARE SENSITIVE TO PROFESSOR MCFADDEN'S INCORRECT ASSUMPTIONS

18. Underlying the changes in the count of unharmed accounts are changes in *which* accounts are harmed. Professor McFadden's model is only capable of assessing which accounts within his 0.1 percent sample are harmed (and he then extrapolates the percentage to the whole proposed class)—and even then, only those accounts that make a paid transaction for apps where he offers a but-for price prediction.[51] I have looked at which accounts within that set ("Professor McFadden's prediction sample") switch from harmed to unharmed, or vice-versa, under the various sensitivities I detail in the body of my report.

19. Each of the following exhibits in this section pertains to a separate sensitivity I run on Professor McFadden's model. As stated above, I assume that all in-app purchase items for the same price and year have the same dollar price change. The first row of these exhibits displays the number (and percent) of Professor McFadden's prediction sample that were calculated to be harmed under Professor McFadden's original methodology, but unharmed under the new sensitivity. Conversely, the second row of these exhibits displays the number (and percent) of Professor McFadden's prediction sample that were calculated to be unharmed under Professor McFadden's original methodology, but harmed under the new sensitivity.

APPENDIX EXHIBIT 1
Accounts whose harmed status changes if but-for commissions were the same as actual commissions through October 2017

Status when 12% but-for commission during entire class period (McFadden baseline)		Status when but-for commissions were the same as actual commissions through October 2017 (new sensitivity)	Number of accounts with status change	
"Harmed"	→	"Unharmed"	42,927	*(43.4%)*
"Unharmed"	→	"Harmed"	52	*(0.1%)*

Source: McFadden Production

Note: These results apply Professor McFadden's methods exactly, except that they set but-for world commisisons equal to actual-world commissions through October 2017. After this, all apps pay a 12 percent commission. 2017 is treated as two separate years: January through November; and November through December.

[51] McFadden Report, ¶ 241.

Appendix E

APPENDIX EXHIBIT 2
Accounts whose harmed status changes if apps under $10 million in lifetime revenue paid same commissions in but-for world

Status when uniform, 12% but-for commission (McFadden baseline)		Status when first $10M lifetime revenue for each app faces actual world commission in but-for world (new sensitivity)	Number of accounts with status change	
"Harmed"	→	"Unharmed"	13,442	*(13.6%)*
"Unharmed"	→	"Harmed"	121	*(0.1%)*

Source: McFadden Production

Note: These results apply Professor McFadden's methods exactly, except that they require an app to reach $10 million in lifetime revenue to qualify for the lower, 12 percent but-for commission Professor McFadden proposes; if an app ever reaches that threshold, I assume it pays the 12 percent commission on *all* transactions, including the first $10 million, in order to be conservative. Otherwise, the app pays the same commission in the but-for world that it paid in the actual world.

APPENDIX EXHIBIT 3
Accounts whose harmed status changes if free apps can raise their prices in the but-for world

Status when free apps excluded (McFadden baseline)		Status when free apps included (new sensitivity)	Number of accounts with status change	
"Harmed"	→	"Unharmed"	25,897	*(26.2%)*
"Unharmed"	→	"Harmed"	529	*(0.5%)*

Source: McFadden Production

Note: These results apply Professor McFadden's methods exactly, except that they (1) include the apps accounting for the top 70 percent of downloads instead of Professor McFadden's top 70 percent of revenue (in any year, within their genre); and (2) they allow free apps to change their prices in the but-for world. Specifically, they treat free apps as paid download apps with actual world prices of $0.00 and actual world commissions of 30 percent. Because the set of apps for which a but-for price is computed has changed, so has the set of consumers with a harm determination. These results focus on the consumers receiving a harm determination both under Professor McFadden's original analysis and under this new analysis.

APPENDIX EXHIBIT 4
Roblox accounts whose harmed status changes when item-level prices are used in the but-for world

Status when using app-level prices to estimate but-for world prices (McFadden baseline)		Status when using item-level prices to estimate but-for world prices (new sensitivity)	Number of accounts with status change	
"Harmed"	→	"Unharmed"	703	*(14.7%)*
"Unharmed"	→	"Harmed"	0	*(0.0%)*

Source: McFadden Production

Note: These results apply Professor McFadden's methods exactly, except that they allow Roblox to set but-for world prices for each in-app purchase item separately. The analysis only considers accounts that made a paid Roblox transaction.

Appendix E

APPENDIX EXHIBIT 5
Accounts whose harmed status changes when profit margin constraints are removed

Status when imposing constraints (McFadden baseline)		Status when removing constraints (new sensitivity)	Number of accounts with status change	
"Harmed"	→	"Unharmed"	13,121	*(13.3%)*
"Unharmed"	→	"Harmed"	2,974	*(3.0%)*

Source: McFadden Production
Note: These results apply Professor McFadden's methods exactly, except that they remove his profit margin constraints.

F. PROOFS AND DERIVATIONS

F.1. Professor McFadden's model predicts that apps with negative marginal costs, including free apps, will raise their prices in the but-for world

20. From McFadden Report, n. 248, the download price should satisfy

$$p_{jt}^{d} = -Q_{jt}\left(\frac{\partial Q_{jt}}{\partial p_{jt}^{d}}\right)^{-1} + \frac{c_{jt}^{d}}{1-\tau},$$

which, as in McFadden Report, Appendix E, ¶ 36 can be rewritten as

$$c_{jt}^{d} = (1-\tau)\left(\frac{1}{\alpha^{d}} + p_{jt}^{d}\right).$$

21. From McFadden Report, Appendix E, ¶¶ 36, 41, the change in price for a paid download app between the but-for and real worlds can be written as

$$p_{jt}^{d\,BF} - p_{jt}^{d\,RW} = \frac{c_{jt}^{d}}{1-\tau^{BF}} - \frac{c_{jt}^{d}}{1-\tau^{RW}},$$

which will be positive for $\tau^{BF} < \tau^{RW}$ whenever $c_{jt}^{d} < 0$.

22. In fact, any paid download app with negative marginal costs will increase its price in the but-for world. The proof is similar for p_{jt}^{IAP}.

23. As I discuss in §6.1, the most straightforward application of Professor McFadden's model to free apps assumes that they are paid download apps with an optimal price $p_{jt}^{d} = 0$ and a 30 percent actual world commission. Professor McFadden's model assigns free apps a marginal cost of $c_{jt}^{d} = (1-\tau^{RW})\left(\frac{1}{\alpha^{d}} + 0\right) < 0$, i.e., free apps have negative marginal costs, since $\alpha^{d} < 0$ (as Professor McFadden estimates) and $1 > \tau > 0$ (as Professor McFadden measures). Thus free apps will raise their prices in the but-for world similar to paid download apps with low prices and negative marginal costs.

F.2. Apps with zero marginal costs do not change their prices in the but-for world

24. From McFadden Report, Appendix E, ¶¶ 36, 41, the change in price for a paid download app between the but-for and real worlds can be written as

$$p_{jt}^{d\ BF} - p_{jt}^{d\ RW} = \frac{c_{jt}^{d}}{1-\tau^{BF}} - \frac{c_{jt}^{d}}{1-\tau^{RW}},$$

which will be zero whenever $c_{jt}^{d} = 0$. The proof is similar for p_{jt}^{IAP}.

F.3. Professor McFadden's constraints on profit margins is mathematically equivalent to constraining estimated consumer price sensitivity

25. Per McFadden Report, Appendix E, ¶ 33, the average margin for paid download apps, on which Professor McFadden imposes bounds, is

$$\overline{m^1} = \frac{1}{N}\sum_{j,year} \frac{p_{j,year}^{d} - c_{j,year}^{d}}{p_{j,year}^{d}}.$$

26. Per McFadden Report, Appendix E, ¶ 36, marginal cost is

$$c_{j,year}^{d} = (1 - \tau_{j,year}^{d})\left(\frac{1}{\alpha^{d}} + p_{j,year}^{d}\right)$$

for paid download apps.

27. As such, the app download consumer price sensitivity can be written as

$$\alpha^{d} = -\frac{\frac{1}{N}\sum_{j,year} \frac{1-\tau_{j,year}}{p_{j,year}^{d}}}{\overline{m^1} - \frac{1}{N}\sum_{j,year} \tau_{j,year}},$$

a simple function of the average margin, prices, and commission rates of the paid download apps.

28. Similarly, the average margin for free download apps with in-app purchases is

$$\overline{m^2} = \frac{1}{N}\sum_{j,year} \frac{p_{j,year}^{IAP} - c_{j,year}^{IAP}}{p_{j,year}^{IAP}},$$

and

$$c_{j,year}^{IAP} = (1 - \tau_{j,year}^{IAP})\left(\frac{1}{\alpha^{IAP}} + p_{j,year}^{IAP}\right),$$

so the in-app purchase consumer price sensitivity is

$$\alpha^{IAP} = -\frac{\frac{1}{N}\sum_{j,year}\frac{1-\tau_{j,year}}{p_{j,year}^{IAP}}}{\overline{m^2} - \frac{1}{N}\sum_{j,year}\tau_{j,year}},$$

a simple function of the average margin, prices, and commission rates of the free download apps with in-app purchases.

F.4. More expensive apps tend to have lower profit margins

29. Per McFadden Report, Appendix E, ¶ 33, the yearly profit margin for a paid download app is

$$m_{year} = \frac{p_{j,year}^{d} - c_{j,year}^{d}}{p_{j,year}^{d}}.$$

30. Per McFadden Report, Appendix E, ¶ 36, the relationship between a paid download app's price, marginal cost, the commission rate, and the consumer price sensitivity is

$$c_{j,year}^{d} = (1 - \tau_{j,year}^{d})\left(\frac{1}{\alpha^{d}} + p_{j,year}^{d}\right).$$

31. As such, the profit margin can be rewritten as

$$m_{year} = \frac{p_{j,year}^{d} - (1 - \tau_{j,year}^{d})\left(\frac{1}{\alpha^{d}} + p_{j,year}^{d}\right)}{p_{j,year}^{d}},$$

which simplifies to

$$m_{year} = \tau_{j,year}^{d} - \frac{1 - \tau_{j,year}^{d}}{\alpha^{d} p_{j,year}^{d}}.$$

32. For a given $\alpha^d < 0$ (as Professor McFadden estimates), the profit margin is declining with $p^d_{j,year}$. That is,

$$\frac{\partial m_{year}}{\partial p^d_{j,year}} = \frac{1 - \tau^d_{j,year}}{\alpha^d \left(p^d_{j,year}\right)^2} < 0$$

for $\alpha^d < 0$. The proof is similar for the profit margin for free download apps with in-app purchases, but the stark conclusion does not apply to paid download apps with in-app purchases, since these apps have two prices.

F.5. All apps within the same genre and business model with the same price face the same elasticity

33. From McFadden Report equation (8), the consumer price sensitivity for app downloads can be written as

$$\alpha^d = \frac{\partial Q_{jt}/Q_{jt}}{\partial p^d_{jt}}.$$

34. For paid download apps, the price elasticity of demand for app downloads, $\frac{\partial Q_{jt}/Q_{jt}}{\partial p^d_{jt}/p^d_{jt}}$, can therefore be rewritten as

$$\alpha^d p^d_{jt} = \frac{\partial Q_{jt}/Q_{jt}}{\partial p^d_{jt}/p^d_{jt}}.$$

35. Professor McFadden estimates the consumer price sensitivity, $\widehat{\alpha^d}$, for each genre. Therefore, for paid download apps in (e.g.) the games genre, the price elasticity of demand will be equal for all apps with the same p^d_{jt}. The proof is similar for free download apps with in-app purchases.

F.6. Apps within the same genre and business model with lower prices have lower elasticities

36. As shown above, the price elasticity of demand for app downloads can be written as

$$\alpha^d p^d_{jt} = \frac{\partial Q_{jt}/Q_{jt}}{\partial p^d_{jt}/p^d_{jt}}.$$

37. It therefore directly follows that apps with lower prices have smaller (less negative) elasticities.

F.7. Developers with low elasticities of demand will tend to raise prices in Professor McFadden's but-for world

38. As shown above, the price elasticity of demand for app downloads can be written as

$$\alpha^d p_{jt}^d = \frac{\partial Q_{jt}/Q_{jt}}{\partial p_{jt}^d/p_{jt}^d}.$$

39. It therefore directly follows that app with lower elasticities have lower prices.

40. From McFadden Report, Appendix E, ¶ 36, marginal costs can be written as

$$c_{jt}^d = (1-\tau)\left(\frac{1}{\alpha^d} + p_{jt}^d\right).$$

41. For fixed τ and α^d, it follows that that c_{jt}^d moves in proportion to p_{jt}^d—that is, $\frac{\partial c_{jt}^d}{\partial p_{jt}^d} > 0$. Therefore, developers facing low elasticities of demand will have lower prices, and will therefore tend to have lower marginal costs.

42. For $0 < \tau < 1$ and $\alpha^d < 0$ as estimated by Professor McFadden, apps with low enough prices will actually have *negative* marginal costs. As shown above, apps with negative marginal costs will raise their prices in the but-for world. The proof is similar for free download apps with in-app purchases.

G. HYPOTHETICAL PROFIT MARGIN CONSTRAINTS

43. In Professor McFadden's model, developers of apps with sufficiently low elasticities of demand, or sufficiently low marginal costs, increase their prices to consumers in the but-for world. This makes it critical for Professor McFadden to reliably estimate each app's elasticity of demand and marginal cost in order to determine which consumers are harmed. Professor McFadden purports to use Apple transaction data to estimate consumers' price sensitivity by measuring the relationship between quantities and prices. However, the actual data on prices and quantities plays a limited role in determining his estimates of price sensitivities. I show empirically that it is primarily the imposed profit margin constraints, rather than the underlying consumer data, that drive Professor McFadden's estimated price sensitivities. I do so by changing his profit margin constraints, and showing that the resulting estimates of consumers' price sensitivity track these changed constraints exactly.

44. Appendix Exhibit 6 and Exhibit 7 show the results. For each profit margin bound, I calculate the implied mathematical bounds on the price sensitivity parameter, using the formula from §F.3 above. It is clear that across a wide range of arbitrary profit margin bounds, Professor McFadden's "estimated" price sensitivity parameters—for both categories of apps—coincide exactly with one of the bounds, and change when the bounds are changed. For example, when the profit margin is assumed to be between 60% and 90% for Games apps, the implied app download price sensitivity falls within the range between -1.21 and -0.61, and Professor McFadden's estimated app download price sensitivity is exactly equal to -0.61. In other words, the imposed profit margin constraints entirely drive the consumers' price sensitivity estimates.

Appendix G

APPENDIX EXHIBIT 6
Price sensitivity estimates and hypothetical profit margin constraints for Games apps

	App download		In-app purchases	
Imposed profit margin bounds	**Implied download-price sensitivity bounds**	**Estimated download-price sensitivity**	**Implied in-app purchase price sensitivity bounds**	**Estimated in-app purchase price sensitivity**
[0.60, 0.70]	[-1.21, **-0.91**]	**-0.91**	[**-0.29**, -0.22]	**-0.29**
[0.60, 0.80]	[-1.21, **-0.73**]	**-0.73**	[**-0.29**, -0.18]	**-0.29**
[0.60, 0.90]	[-1.21, **-0.61**]	**-0.61**	[**-0.29**, -0.15]	**-0.29**
[0.50, 0.90]	[-1.80, **-0.61**]	**-0.61**	[**-0.44**, -0.15]	**-0.44**
[0.70, 0.90]	[-0.91, **-0.61**]	**-0.61**	[**-0.22**, -0.15]	**-0.22**
[0.80, 0.90]	[-0.73, **-0.61**]	**-0.61**	[**-0.18**, -0.15]	**-0.18**

Source: McFadden Production

Notes: These bounds are computed by inverting the constraints given in Appendix E, ¶ 33 of the McFadden Report, and then substituting in the actual-world prices and coefficients that Professor McFadden uses.

APPENDIX EXHIBIT 7
Price sensitivity estimates and hypothetical profit margin constraint for Music and Entertainment apps

	App download		In-app purchases	
Imposed profit margin bounds	**Implied download-price sensitivity bounds**	**Estimated download-price sensitivity**	**Implied in-app purchase price sensitivity bounds**	**Estimated in-app purchase price sensitivity**
[0.20, 0.30]	(-Inf, **-100.70**]	**-100.70**	(-Inf, **-4.86**]	**-4.86**
[0.20, 0.40]	(-Inf, **-3.14**]	**-3.14**	(-Inf, **-1.38**]	**-1.38**
[0.20, 0.45]	(-Inf, **-2.12**]	**-2.12**	(-Inf, **-1.01**]	**-1.01**
[0.20, 0.50]	(-Inf, **-1.60**]	**-1.60**	(-Inf, **-0.80**]	**-0.80**
[0.20, 0.60]	(-Inf, **-1.07**]	**-1.07**	(-Inf, **-0.57**]	**-0.57**
[0.20, 0.65]	(-Inf, **-0.92**]	**-0.92**	(-Inf, **-0.49**]	**-0.49**

Source: McFadden Production

Notes: These bounds are computed by inverting the constraints given in Appendix E, ¶ 33 of the McFadden Report, and then substituting in the actual-world prices and coefficients that Professor McFadden uses. The imposed price coefficient bound also include [3.35, +Inf) for download-price coefficient and [3.19, +inf) for in-app purchase-price coefficient.